Foreign Agricultural Economic Report No. 7

Sources of Change in Mexican Agricultural Production, 1940 - 65

Mexico: Census Regions, States and Territories (and their capitals).

PACIFIC NORTH: 1 = Baja California North (Mexicali). 2 = Baja California South (La Paz). 3 = Sonora (Hermosillo). 8 = Sinaloa (Culiacán). 12 = Nayarit (Tepic).

NORTH: 4 = Chihuahua (Chihuahua). 5 = Coahuila (Saltillo). 6 = Nuevo León (Monterrey). 7 = Tamaulipas (Ciudad Victoria). 9 = Durango (Durango). 10 = Zacatecas (Zacatecas). 11 = San Luis Potossí (San Luis Potossí).

CENTRAL: 13 = Aguascalientes (Aguascalientes). 15 = Jalisco (Guadalajaro). 16 = Guanajuato (Guanajuato). 17 = Querétaro (Querétaro). 18 = Hidalgo (Pachuca). 20 = Michoacán (Morelia). 21 = México (Toluca). 22 = Puebla (Puebla). 23 = Federal District (Mexico City). 24 = Tlaxcala (Tlaxcala). 26 = Morelos (Cuernavaca).

PACIFIC SOUTH: 19 = Colima (Colima). 25 = Guerrero (Chilpancingo). 27 = Oaxaca (Oaxaca). 29 = Chiapas (Tuxtla).

GULF: 14 = Veracruz (Jalapa). 28 = Tabasco (Villahermosa). 30 = Campeche (Campeche). 31 = Yucatán (Mérida). 32 = Quintana Roo (Chetumal).

Sources of Change in Mexican Agricultural Production, 1940 - 65

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ABSTRACT

During 1940-65, Mexico's agricultural output grew 4.6 percent a year while population rose 3.3 percent. The rapid expansion of agricultural production was primarily due to increased use of purchased inputs (including fertilizer and better seed varieties), land, livestock capital, and hired labor, all of which were about equal in importance. Output per worker increased about 3 percent a year. Two Government programs—land reform and irrigation development—contributed to productivity increases. By 1965, public irrigation had affected over 2 million hectares of farmland. Inputs used on this land were those associated with modern agriculture, but such inputs were of little significance on most of the land outside irrigated regions. Under the land reform program, land was expropriated from large farms and distributed to 2.3 million previously landless Mexicans. By 1965, land reform had affected 29 percent of the arable land and 43 percent of the cropland.

Key Words: Mexico, agricultural productivity, irrigation, land reform, crop yields, prices, technological progress.

Conversion Factors

1 Peso = U.S.$0.08
1 hectare = 2,471 acres

Use of company names in this publication is for identification only and does not imply endorsement by the U.S. Department of Agriculture.

FOREWORD

To provide better knowledge for planning and implementing development programs in the less developed countries, the Agency for International Development asked the Economic Research Service (ERS), U.S. Department of Agriculture, to study the factors associated with differences and changes in agricultural production in underdeveloped countries.

Phase 1 of the research, which compared and analyzed growth rates in agricultural output and factors affecting them, was reported in *Changes in Agriculture in 26 Developing Nations, 1948-63* (Foreign Agricultural Economic Report No. 27, Economic Research Service, U.S. Department of Agriculture, November 1965).

Phase 2 of the research involved making a detailed analysis of the sources of increase in agricultural output in Greece, Taiwan, Mexico, Brazil, Columbia, India, and Nigeria. ERS agricultural economists conducted these studies in cooperation with research organizations in each country. Results were summarized in *Economic Progress of Agriculture in Developing Nations, 1950-68* (Foreign Agricultural Economic Report No. 59, Economic Research Service, U.S. Department of Agriculture, May 1970).

This report is the phase 2 study on Mexico. It describes and analyzes the agricultural development process during 1940-65. Substantial background data is provided as an introduction to this important period in Mexico's development. Changes in farm output, food consumption, and foreign trade after 1940 are examined and sources of the increased production and productivity are identified. Particular attention is paid to the roles of major public policies in Mexico's agricultural development.

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Many of the annual data series, as well as the unpublished county-level information, used in this report were freely supplied by the Mexican Directorate of Agricultural Economics and the Directorate of Statistics. Lic. Ruben Cleason, Director General of Statistics, was particularly helpful in arranging for access to the county data of the 1960 Mexican Census of Agriculture.

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SUMMARY

Mexico's agricultural productivity increased dramatically during 1940-65, primarily as a result of major land reform and irrigation programs begun earlier. The first effects of these and other Government programs appeared in 1940; before that date agricultural production had just been keeping pace with population growth. During 1940-65, the following average annual increases occurred: gross farm output rose 4.6 percent, well in excess of the 3.0-percent growth rate in population; total input increased 2.6 percent; land increased 2.0 percent, and output per hectare rose at a faster rate, 2.6 percent; agricultural employment increased 1.5 percent, while output per man increased 3 percent; use of purchased inputs—including fertilizers, seeds, insecticides, and irrigation water—rose rapidly at 8.4 percent; livestock capital inputs rose about 2.5 percent; and the total effective stock of machinery, implements, and work animals increased 5.0 percent.

Diets of the people improved. The balance of agricultural exports over imports increased by more than 8.0 percent annually, and sales of farm commodities became the most important source of foreign exchange earnings.

About 60 percent of the average annual increase in total input was accounted for by working capital inputs (including purchased inputs, hired labor, and power and implements). Family labor, land, and livestock capital accounted for 40 percent. Most significant is that output per unit of input, or total factor productivity, increased an average of 2.0 percent a year during 1940-65.

The Government's major agricultural policies have been concerned with improving farmland quality, which is of poor quality relative to other farmland in Latin America; increasing the quantity available for crops; and improving the distribution of land ownership. These policies account for much of the post - 1940 increase in Mexican agricultural productivity.

Irrigation, dating from the mid-1920's, has been the principal tool for increasing the quantity and quality of land. During 1963-65, about 15 percent of total public investment was applied to water projects. As water was supplied to dryland farm areas, agricultural "oases" with concentrations of farmers developed. Purchased inputs could be supplied more cheaply to these irrigated regions. Public and private input suppliers began to locate there, providing many free information services that increased output through more effective use of inputs. Also, technological features of production under irrigation demanded greater use of purchased inputs. The result was rapid adoption of fertilizers, seeds, insecticides, and power and implements and significant increases in agricultural productivity.

Land reform has been used continually to improve the distribution of land resources. Since 1917, over 46.5 million hectares have been expropriated from large farms and distributed to 2.3 million previously landless peasants, or "ejidatarios," who presently represent half of Mexico's farmers.

For the "ejido" structure, returns to the family labor input are low, partly because the Mexican Agrarian Code prohibits rental or sale of ejido farms. This nonalienation provision means that the ejidatario's return to family labor is lower than might be obtained in alternative forms of employment. If an ejidatario quits farming, he loses the returns from the land he leaves behind. Returns from land do offset, of course, part of the higher salary which might be earned elsewhere. However, because high-return inputs other than family labor represent a larger proportion of total inputs than do family labor, net increases in output resulted from transferring resources from the private to the ejido sector.

Other public programs have complemented land reform and irrigation. Notable examples are agricultural price support, research and extension, farm credit, and rural education programs. Underlying the success of most of these has been an uncommon flexibility in the management of specific development programs; a commitment to agricultural policies that has continued over a long period of years; a concentration of resources on a limited number of development projects; and the maintenance of essential economic incentives to farmers.

I.—INTRODUCTION

Two features have distinguished the process of agricultural development in Mexico. First, production has increased over a long period of time at rates easily exceeding those achieved by other major Latin American nations, except Venezuela *(26)*.[1] Second, Mexican public policy has had a significant bent for agriculture. Since the mid-1930's, the Government has made exceptional commitments to increasing production levels and to improving the distribution of agricultural resources. Major public policies have involved large-scale irrigation projects and reform of farmland ownership.

This study is directed towards both these features. Its primary aim is to explain the rapid expansion in farm output which occurred during 1940-65. A secondary purpose is to link irrigation and land reform developments to changes in the use of particular farm inputs and in returns to these inputs.

Chapter II presents highlights of Mexican agricultural development, with attention given to unusual features and international comparisons. Chapter III contains the general record of growth in total agricultural production, food consumption, and foreign trade for 1940-65. Chapter IV presents estimates of changes in total input and productivity for the period and describes in detail changes that took place in each category of farm inputs. Chapter V relates input use to major public policy developments.

The appendix summarizes results obtained from estimating production functions on cross-section, county-level data from the 1960 Mexican Agricultural Census. It concludes by drawing, from those estimates, implications of the effects of public policy on productivity.

[1]Numbers in parentheses refer to items in Literature Cited, p. 42.

II.—MEXICAN AGRICULTURE: A PERSPECTIVE

Mexico is a major nation in Latin America. In population, it is second only to Brazil; it ranks third in share of gross domestic product (GDP) originating in farm and nonfarm sectors, and its arable land area about equals all such land in South America outside Brazil and Argentina (table 1). Its rate of GDP growth in agriculture from 1951 to 1964 ranked third in Latin America. Its rate of growth in nonfarm GDP was the

Table 1.—Selected economic data, Latin American nations

Country	Percentage of Latin American[1]		1960 population	Annual rate of population increase, 1950-60	Proportion[1] of labor force in agr.	Annual rate of increase, 1951-64	
	Gross agr. prod.	Gross non-agr. prod.				Gross agr. prod.	Gross non-agr. prod.
	Percent	*Percent*	*Millions*	*Percent*	*Percent*	*Percent*	*Percent*
Mexico	13.3	17.8	35.0	3.2	54.2	4.2	6.0
Costa Rica	0.9	0.6	1.2	4.1	49.1	2.8	5.5
Dominican Republic			3.0	3.2	61.5		
El Salvador	1.2	0.8	2.4	3.1	60.2	3.4	5.4
Guatemala	2.1	1.4	3.8	2.9	68.2	3.7	4.6
Haiti	1.1	0.5	4.1	2.1	83.2	1.2	1.7
Honduras	1.2	0.5	1.9	3.3	66.9	3.3	3.9
Nicaragua	1.0	0.5	1.5	3.4	59.5	4.6	5.9
Panama	0.7	0.6	1.1	3.0	46.3	3.9	5.8
Argentina	14.9	19.3	20.9	1.8	19.2	1.9	2.7
Bolivia	0.6	0.5	3.7	2.1	64.1	1.2	1.4
Brazil	37.7	27.8	70.6	3.0	51.6	4.8	5.3
Chile	2.6	5.0	7.6	2.5	30.7	3.2	3.8
Colombia	11.3	7.5	15.5	2.8	54.1	3.1	4.6
Ecuador	1.7	1.0	4.3	3.2	55.6	3.9	4.6
Paraguay	0.8	0.5	1.8	2.4	52.2	2.5	2.9
Peru	3.1	3.1	10.9	2.6	49.8	3.4	5.3
Uruguay	2.1	2.1	2.5	1.2	17.9	0.5	1.2
Venezuela	3.7	10.5	7.3	3.8	32.2	5.7	6.0
Total or average	100.0	100.0	205.9	2.8	52.2	3.6	4.6

Footnote at end of table.

Continued—

Table 1.—Selected economic data, Latin American nations—Continued

Country	Arable land	Cultivated land	Irrigated as a % of cultivated	Arable land per worker	Gross dom. prod. per worker, 1963-65: Agr.	Nonagr.	Agr./nonagr.
	Million hectares	*Percent*	*Percent*	*Hectares*	*1960 U.S. dollars*	*1960 U.S. dollars*	*Ratio*
Mexico	103.3	23.1	14.7	16.8	350	2,046	0.17
Costa Rica	1.5	65.3	2.5	8.0	776	1,616	0.48
Dominican Republic	1.7	84.3	9.2	3.4			
El Salvador	1.2	59.6	0.0	3.0	404	1,394	0.29
Guatemala	2.1	74.3	2.0	3.2			
Haiti	0.9	42.5	17.6	0.6			
Honduras	1.7	52.1	7.4	4.5	637	967	0.66
Nicaragua	2.6	75.2	0.0	9.1	593	1,346	0.44
Panama	1.4	90.2	1.1	8.8	699	1,989	0.35
Argentina	143.9	23.3	4.5	98.4	1,856	2,091	0.89
Bolivia	14.3	21.6	2.1	21.3			
Brazil	160.5	42.3	0.2	13.7	534	1,266	0.42
Chile	14.5	29.4	31.9	19.9	682	1,978	0.34
Colombia	19.7	25.7	4.5	14.3			
Ecuador	3.3	62.4	1.1	4.2	364	799	0.45
Paraguay	10.7	8.0	0.9	33.4	428	736	0.58
Peru	11.4	22.7	46.7	7.3	381	1,178	0.32
Uruguay	16.1	14.0	1.2	88.5			
Venezuela	19.1	27.2	4.7	24.7	837	4,302	0.19
Total or average	537.8	30.0	5.4	17.6	558	1,769	0.31

Country	Per capita consumption, 1962-65: Calories	Proteins	Change, 1950/51-1960/65: Calories	Proteins	Literacy rate[1]	Yields of selected crops, 1962/63: Beans	Corn	Lint cotton	Rice	Wheat
	Units	*Grams*	*Percent*	*Percent*	*Percent*	*Kilos per hectare*	*Kilos per hectare*	*Kilos per hectare*	*Kilos per hectare*	*Kilos per hectare*
Mexico	2,640	73	11.9	15.9	71.0	390	940	640	2,160	1,940
Argentina	3,040	86	-2.3	-11.8	91.0	1,140	1,650	250	3,410	1,460
Brazil	2,850	62	21.3	5.1	61.0	670	1,300	180	1,780	910
Chile	2,370	80	1.3	12.7	84.0	920	2,100		2,520	1,500
Colombia	2,130	49	-10.1	-10.9	62.0	550	1,100	450	2,160	980
Ecuador	1,970	50	-3.9	0.0	68.0	480	650	160	1,690	920
Paraguay	2,580	66			68.0	750	1,250	210	2,280	700
Peru	2,160	55	4.3	1.9	61.0	990	1,390	610	3,390	990
Uruguay	2,970	94	1.0	-5.1	91.0		870	300	3,800	1,130
Venezuela	2,240	60	-1.8	1.7	80.0	540	1,120	300	1,490	540
South American average						680	1,360	230	1,870	1,330

[1] Refers to 1960 or after for all countries except Bolivia, Colombia, Guatemala, and Haiti, for which the reference year is either 1950 or 1951.

Source: *(2, 15, 26, 43).*

highest in Latin America, equaled only by that of Venezuela. Population growth was likewise more rapid than the mean of the region.

Mexico also presents a contrast between high rates of farm output growth and low average product per farmworker. Farm output per agricultural worker in 1963-65, at US$350, was less than two-thirds of the regional average and was lowest among the Latin American countries for which comparable data are available (table 1).

Three factors, discussed more fully later in this study, provide insight into this unique situation. First, the quality of most of Mexico's northern land outside irrigated regions is low by Latin American standards of arable land. Second, Mexico's agricultural development effort has been concentrated on a small segment of the nation's land and farmers. Irrigation, the cornerstone of the effort, led to rapid expansion of output of a few crops on only a small fraction of Mexican farmland. Finally, Mexico's land reform policy has transformed many landless workers into small farm operators. Although their incomes are higher than before reform, they are still relatively low.

The effects of the first two factors can be seen in the comparative data of table 1 on crop yields. Among Mexico's major crops, cotton and wheat yields are higher than those in most South American countries. Cotton is almost entirely irrigated. Although wheat historically has

been classed as a subsistence crop in Mexico, its production now is geographically concentrated and most wheat land is irrigated. Yields of corn and beans, however, are well below the average for South America; output is geographically dispersed and only a little of the land planted to these crops is irrigated.

THE RESOURCE SETTING[2]

The natural endowment of much of Mexico's farmland is poor in Latin American terms, since roughly half of it does not receive adequate rainfall. In a real sense, land is a scarce resource.

The southern half of Mexico's land area shares the torrid zone with Central America and the northern half of South America; historical patterns of land use and settlement in the two areas are similar. The Tropic of Cancer crosses just above the tip of the peninsula of Lower California. South of this boundary, the country is dominated by the Central and Southern Mesas and the Chiapas Highlands. These regions are 4,000 to 8,000 feet above sea level, and their altitude counteracts latitude to preserve about the same mean temperature over the entire area.

The Central Mesa is by far the most densely populated region of Mexico. Its climate is typical of tropical highlands, with a long growing season and mild summers and winters. Ample rainfall from May through October allows cultivation without irrigation. Crop production is concentrated in the high flats of the "Bajio," north of Mexico City; in the Valleys of Mexico and Puebla State, east of the Capital; and in the Valleys of Toluca and Lerma to the West. The steep slopes of these valleys are also farmed but generally yield meager harvests. The thin topsoil has been badly eroded by years of intensive cultivation.

The Southern Mesa and Chiapas Highlands have some of the roughest mountains and gorges in the country and lack the extensive valleys and high plateaus of the Central Mesa. Many Mexican farmers cultivate corn on badly eroded slopes and graze small herds of cattle in the limited areas suitable for agriculture. Timber is cut from mountain forests. Life is more rural than in any other region of Mexico. Agriculture is traditional.

The northern half of Mexico lies outside the torrid zone and is distinguished by low altitudes, vast stretches

[2] This section draws heavily on (*19, 22, 47*).

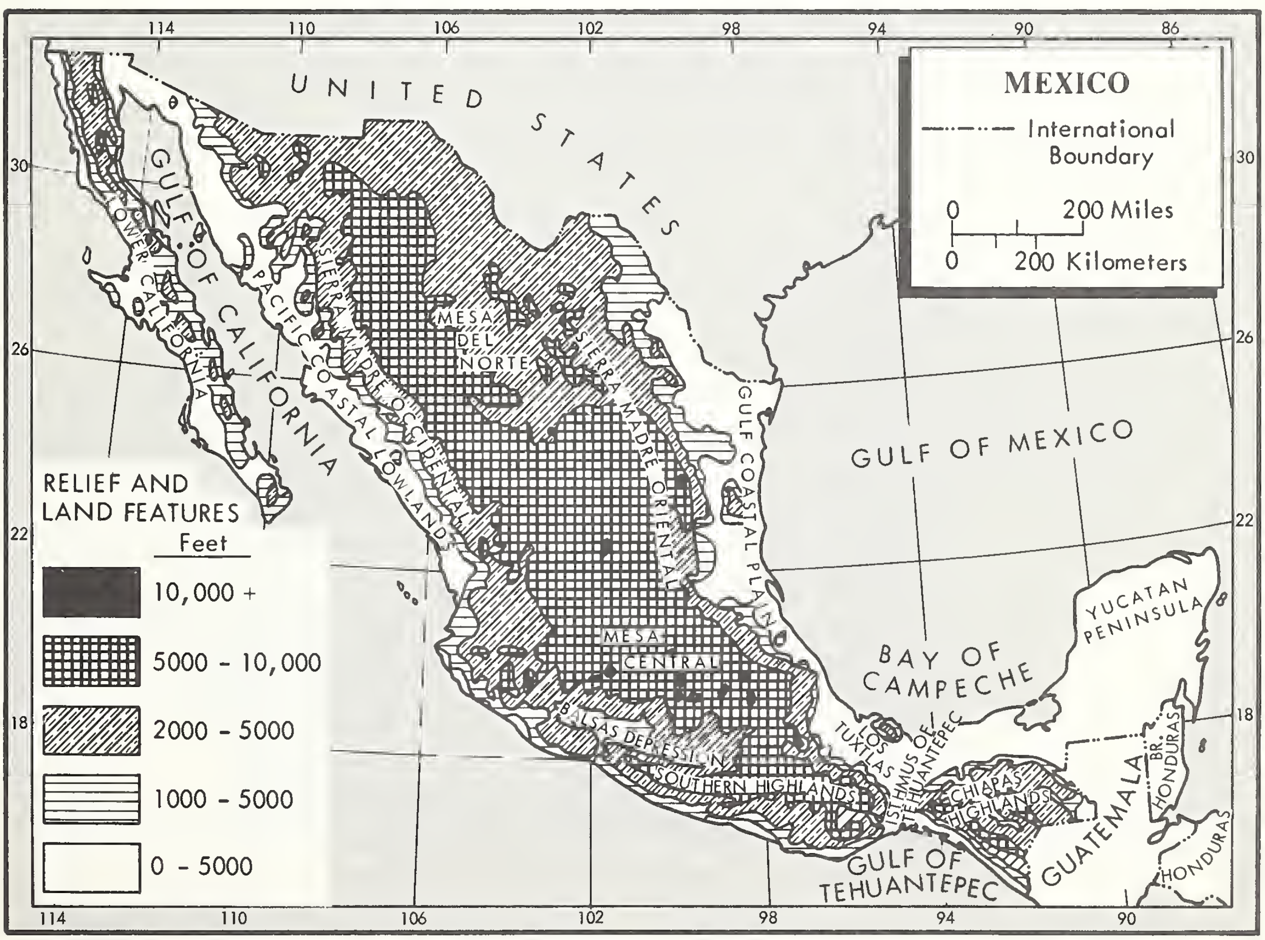

Figure 1.—Topography of Mexico.

of level land, and little precipitation. Crop production in most of this region is nearly impossible without irrigation, since much of it is arid and semi-arid (fig. 2).

Irrigation and transportation were primary factors leading to the development of this dry half of the Mexican Republic. Ownership of the northern lands was derived from grants made by the Spanish Crown. Where farming was first undertaken in earnest, livestock and crops for export figured heavily in production. Cotton, for example, spurred developments on the huge (400,000 hectares) Hacienda San Lorenzo in the Comarca Lagunera Region, on the Hacienda La Santenana further north and nearer the Gulf Coast, and in the Mexicali region near the U.S. border in Lower California. To expand production of export crops, the early pioneers constructed dependable irrigation systems and opened new land to cultivation. Every drop of water was said to produce a boll of cotton!

Developments were hastened by improved transportation and the desire to gain access to the United States. During the time of the Restored Republic (1867-77), seven rail lines were projected to unite the North with the Capital. The most important of these, and the first to be completed (1884), went from Mexico City through the commercial center of the present-day Comarca Lagunera agricultural region to Ciudad Juarez on the border. Rapid settlement of the North followed. Data reported by Cosio Villegas *(7)* show that migration to the Laguna, following the advent of the railroad, was higher than to any other region outside the Federal District with the exceptions of the States of Nuevo Leon and Veracruz—both of which also enjoyed early progress in transport facilities.

As elsewhere in Latin America, Mexico's lowland tropics have experienced rapid development in recent years. However, settlement in these lowland areas has been slower than in the north of Mexico. Heavy rains, extreme heat, high humidity, and disease have discouraged rapid settlement along the Gulf Coastal Plain, the Isthmus of Tehuantepec, and the western extremes of the Southern Escarpment. The thin, lateritic soils of the southern part of the Gulf plain, high winds

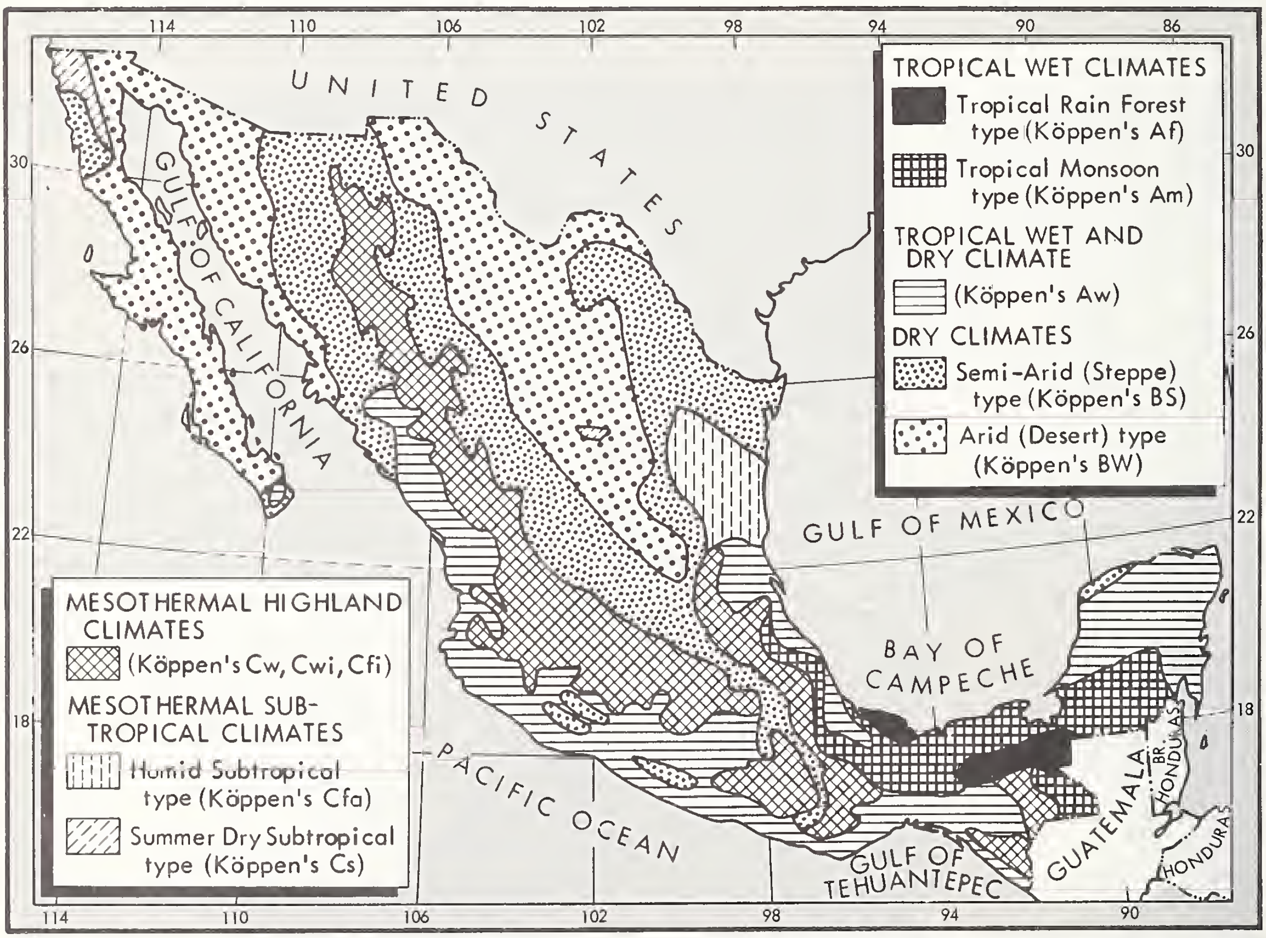

Figure 2.—Climates of Mexico, shown in modified Köppen-type regions and subtypes.

A = tropical forest climates—coolest month above 64.4°F. BS = semi-arid; BW = desert. C = mesothermal forest climates—coldest month above freezing, but below 64.4°F.; a = warmest month above 71.6°F.; f = constantly moist—rainfall throughout the year; i = isothermal climate—average annual range less than 10°F; m = monsoon rain—short dry season, but enough total rainfall to support rain forest; s = dry season in summer; w = dry season in winter.

from the ocean which sometimes blow violently over the central and northern parts of the plain, and the ruggedness of the western topography of the hot zone add to the commonly disagreeable features of Latin American lowlands. Thus, apart from the settlement of Veracruz State, encouraged by the introduction of Zebu cattle, and the development of cotton around Tampico on the northern Gulf Coast, dynamic change in Mexico's hot country has been limited to port towns and areas along the coastal belt of the Gulf Ocean with rich deposits of oil.

AGRICULTURAL POLICIES

Mexico's two major agricultural policies have been concerned with the "scarce" land resource. The Government has instituted reform designed to improve the distribution and ownership of land. And it has developed irrigation projects to improve the quantity and quality of land available.

Other Government programs that complement and support these two policies include seed improvement, fertilizer, disease control, soil conservation, and credit programs. Agricultural price supports and crop insurance programs attempt to stabilize prices and income of all farmers including those for whom irrigation is not yet available. Livestock improvement programs upgrade the productivity of animals most suited to the arid zones. Extension and education programs, with special emphasis on rural communities, work to increase literacy and skill levels of the Mexican people.

More details on these programs appear in later chapters. A brief review is provided here to give better perspective and essential background information.

Irrigation

Public irrigation development in Mexico dates from the creation of the National Commission of Irrigation in 1926. Since 1947, the Secretariate of Water Resources (SRH) has had the responsibility for development and administration of water projects.

Three basic programs have been carried out by these agencies: development of large irrigation projects on land of 5,000 or more hectares; development of projects on land of less than 5,000 hectares in extremely dry, less suitable areas; and rehabilitation of areas in which inadequate irrigation and drainage have led to waterlogging, soil deterioration, and high salinity.

Since before 1926, about 1.5 million hectares of cropland have been privately irrigated. As illustrated in figure 3, this area has remained about constant. The area

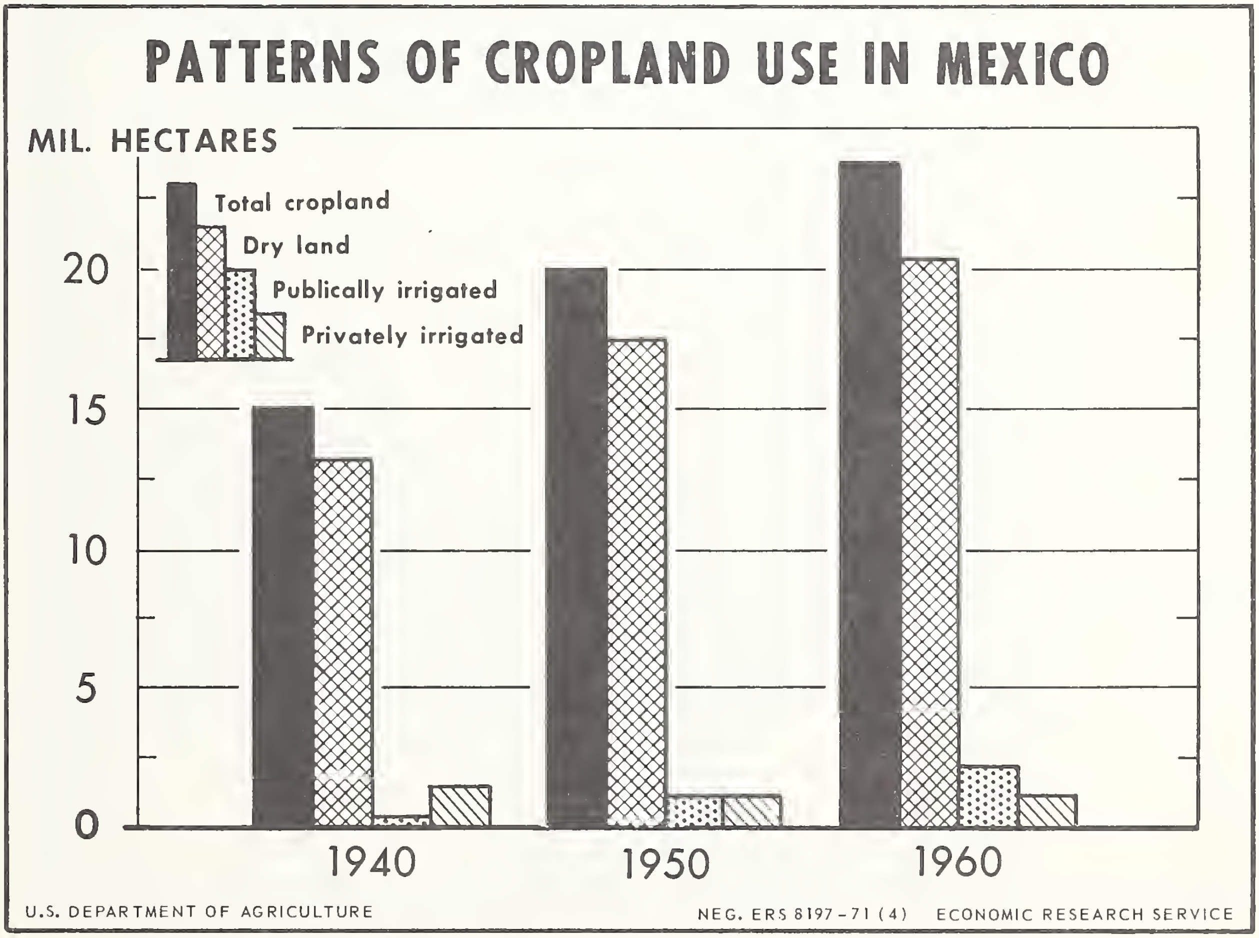

Figure 3

irrigated under Government projects has increased to well over 2 million hectares. The Mexican Government's irrigation investments have been consistently larger than its spending in any other single agricultural program (table 2). In fact, in the total economy, only transportation and communication projects have received more public funds.

Land Reform

The Mexican Agrarian Code, based on Article 27 of the 1917 Constitution, states that private farms in excess of 200 hectares may be expropriated.[3] The land so taken is granted to a group of 20 or more native-born Mexicans who live nearby (within 4 miles). Owners of large private farms may select and retain 200 hectares and they have the legal right to compensation for the land taken from them. But only a few have been paid; confiscation has been the rule. The recipients of expropriated land, termed "ejidatarios," cannot alienate, encumber, transfer or otherwise divide their parcels.

The final authority in all matters of land reform is the President of the Republic, but temporary land grants can be made by a state governor. Land expropriation and distribution are administered by the Department of Agrarian and Colonization Affairs, an autonomous federal agency directly responsible to the President. Advisory councils function at both state and federal levels to provide additional staff support to state governors and the President.

In a half-century of Mexican land reform, over 46.5 million hectares have been distributed to 2.3 million ejidatarios *(10)*. The effect has been a complete transformation of the structure of farming. Ejidatarios have now assumed a prominent tenure position (table 3).[4] Most ejidatarios are in the Central Mesa, the Chiapas Highlands, and the "hot country" of the Territory of Quintana Roo and the States of Campeche, Morelos, and Yucatan (fig. 4). This is mainly because more than half of Mexico's land reform took place during the 1934-39 sexennium of President Lazaro Cardenas. At that time, the south-central highlands and parts of the hot country had the highest concentrations of population and private land ownership, necessary conditions for land reform under Mexican law. High population concentration lent itself to the 4-mile limit applied to residence of a recipient of expropriated land, and concentrated private ownership, of course, frequently satisfied the 200-hectare size limitation.

An exception to this pattern of holdings is the concentration of ejidatarios in the States of Sinaloa and Nayarit at the southern extreme of the Western Littoral. This concentration illustrates an important link between land reform and irrigation in Mexico's agricultural policy, which has maintained roughly equal shares of

[3] "Affectable" private property is defined as holdings exceeding 200 hectares of unirrigated land; 100 hectares of irrigated land; 150 hectares planted to cotton; 300 hectares in bananas, sugarcane, coffee, cocoa, fruit trees or henequen; or enough pastureland to maintain 500 head of bovine cattle.

[4] The number of ejidatarios (1.6 million) implied by table 3 is less than the 2.3 million figure cited in the text by reason of abandonments.

Table 2.—Investments of the public sector, Mexico, 1935-63

Sector	1935-40	1941-46	1947-52	1953-58	1959-63
	Percentage distribution				
Agricultural investments	17.8	15.7	22.0	13.0	8.9
Irrigation works	16.8	15.0	16.2	12.2	8.5
Other	1.0	.7	5.8	.8	.4
Industrial investments	9.3	10.2	18.9	30.3	35.3
Electricity	.7	2.2	6.8	6.7	17.3
Gas and oil	8.6	8.0	12.0	19.8	13.7
Other	---	---	.1	3.7	4.3
Communication and transportation investments	51.4	51.6	40.2	36.3	30.2
Roads	18.9	23.3	16.0	14.7	11.9
Railroads	29.4	26.0	21.3	16.0	11.4
Other	3.1	2.3	2.9	5.7	6.8
Social investments	8.3	12.9	13.3	14.3	21.3
Public housing	---	---	1.5	1.5	4.9
Hospitals	.7	1.5	1.5	1.5	4.8
School and research facilities	2.4	1.2	3.0	2.5	2.5
Other	5.2	10.2	7.3	8.7	9.1
Miscellaneous	13.3	9.5	5.6	6.1	4.2
	Million pesos				
Total outlays	947	4,309	14,091	29,674	50,729

Source: (*16*, p. 12).

Table 3.—The structure of farming in Mexico, 1960

Item	Unit	Private sector units			Ejido sector units	All farms
		Large[1]	Small[2]	All private		
Gross farm output	Million pesos	12,890	1,390	14,280	7,331	21,611
Crop output	do.	7,703	823	8,525	5,870	14,396
Livestock output[3]	do.	5,187	567	5,754	1,461	7,215
Arable land	1,000 bushels	71,660	1,295	72,955	29,943	102,898
Cropland	do.	12,217	1,259	13,476	10,329	23,805
Pastureland	do.	59,443	36	59,479	19,614	79,093
Workers	Thousands	1,261	2,136	3,402	3,163	6,565
Family workers[4]	do.	995	2,104	3,099	3,109	6,208
Full-time hired laborers[5]	do.	271	32	303	54	357
Number of farm units	do.	447	899	1,346	1,598	2,944
Partial productivity measures:						
Output per farm	Pesos	28,836	1,546	10,609	4,588	7,341
Arable land per farm	Hectares	160	1	54	19	35
Workers per farm	Number	2.8	2.4	2.5	2.0	2.0
Output per hectare	Pesos	180	1,073	196	245	210
Crop output per hectare of cropland	do.	631	653	633	568	605
Output per farmworker	do.	10,222	651	4,197	2,318	3,292

[1] Over 5 hectares. [2] Five hectares or less. [3] Excludes output "en poblaciones." [4] Operators plus unpaid family workers. [5] Adjusted for rates of employment.

Source: *(34)*.

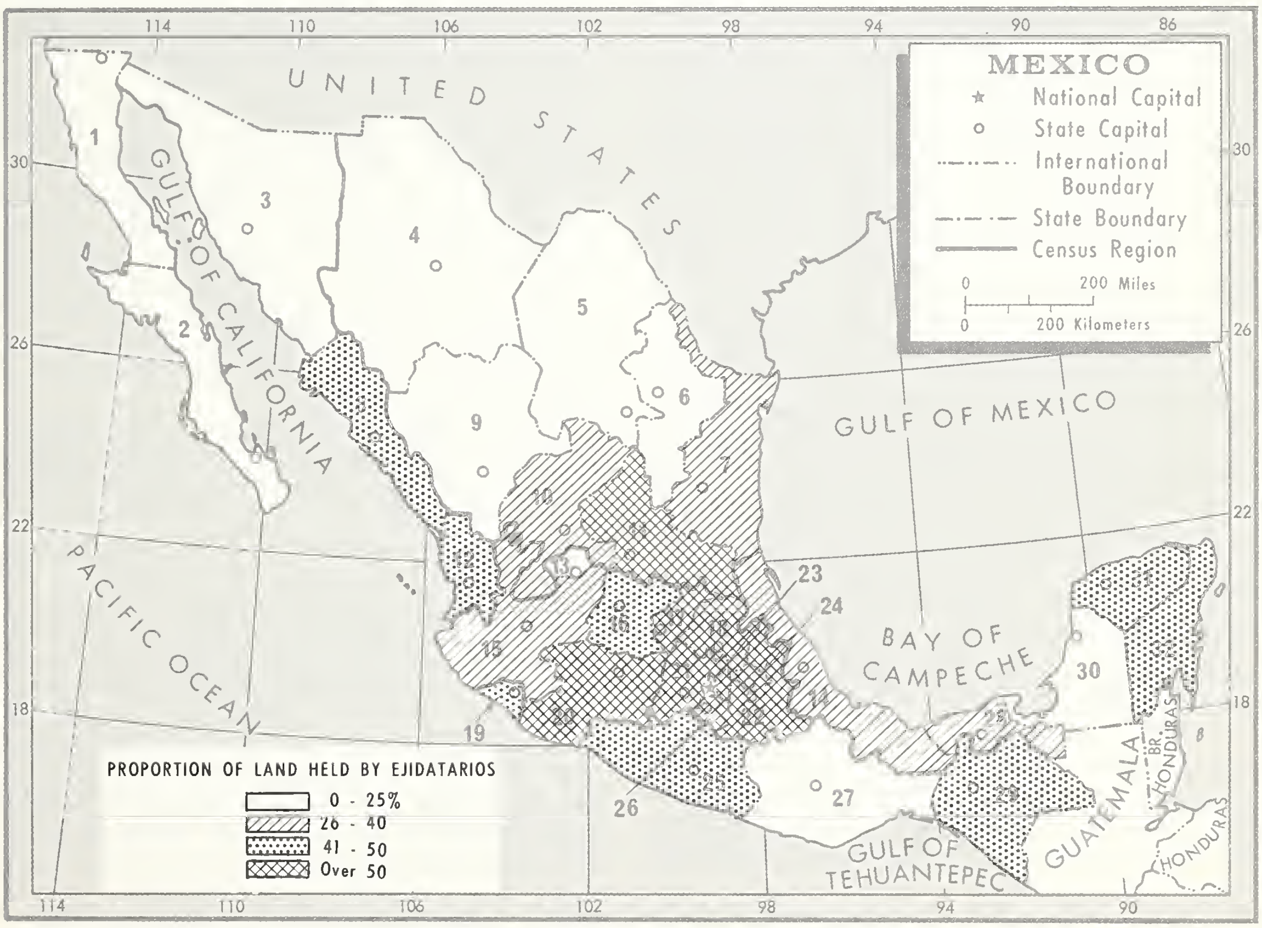

Figure 4.—Proportion of arable land held by ejidatarios.

private and ejido (public) irrigated cropland. These shares are 0.16 for private and 0.14 for ejido *(34)*. The States of Sinaloa and Nayarit most clearly illustrate the policy's operation, as high proportions of the States' arable land are cropped and irrigated by Government projects.

In a half-century of land reform, the well-known Latin American pattern of many private units of less than 5 hectares and relatively few large farms that include most of the farmland has been broken by the emergence of ejidatarios. In 1930, well before major reforms, small private units ("minifundios" of less than 5 hectares) and ejidatarios in Mexico represented about 85 percent of Mexico's farm units, but only 8 percent of all arable land. A relatively few large private farms worked over two-thirds of the land. But by 1960, ejidatarios had acquired 29 percent of Mexico's arable land, 43 percent of the cropland, about half the publicly irrigated land, and 54 percent of all farm units. They produced about one-third of the value of gross farm output.

Ejido farms are small compared with large private units. Per farm in 1960, they produced one-sixth as much as large farms did on about one-eighth as much land. Yet they employed three-fourths as many laborers per farm (table 3). Because production on ejido land is weighted more heavily with crop items, total output per hectare is generally higher; however, 1960 output per hectare of ejido cropland was somewhat lower. Output per worker on ejido farms was only about US $160 in 1960, even though some ejidatarios had left agriculture, which resulted in consolidation of land parcels over the years. The exit of ejidatarios from agriculture is indicated by the fact that 2 million ejidatarios were recorded as having "benefited" by land reform through 1960, while only 1.6 million were reported in the 1960 Census of Agriculture *(10)*.

Although these comparisons between ejido farms and large private farms do not uniformly favor the ejido structure, the data suggest that the ejidatario is better off than the small private farmer who has only a hectare of arable land, annual production of about US $120, and the same number of family members to feed and shelter. This inference is probably valid, even though many small private farmers earn income from sources outside agriculture and ejidatarios generally do not.[5] Further, the net income of US$180 obtained by the average ejidatario in 1960 compares quite favorably with the US$85 earned by the average hired laborer ("peon"), who was employed for only about 3 full-time months at US$28 a month.[6]

[5] Most small private farms are located on the outskirts of villages and urban centers. The farmer and his family workers generally farm parttime. Ejidatarios, on the other hand, are found well outside urban areas, where part-time employment alternatives are more limited.

[6] Net income is gross production less the implicit costs of using all inputs except land and family labor.

The above comparisons indicate the equity of land reform: a person whose alternatives in agriculture might include working as a hired laborer, or perhaps operating a "minifundio," is better off as an ejidatario. These comparisons do not of course answer the important economic question: Is the productivity of agricultural resources enhanced if employed by ejidatarios?

Agricultural Price Supports

In attempting to stimulate production of basic subsistence crops, stabilize their prices, and support farm incomes, the Mexican Government has fixed guaranteed prices on corn since 1949. The price support program was expanded during the 1950's to include wheat, beans, and rice on a regular basis. More recently, dry chile, safflower, cottonseed, eggs, and sorghum have appeared intermittently on the guaranteed price list.

Since April 1965, CONASUPO (Compania Nacional de Subsistencias Populares) has had administrative responsibility for the program. It is an autonomous Government agency, but activities are coordinated with other branches of the Government. For example, the two official agricultural banks purchase products from their clients on behalf of CONASUPO and aid in identifying sellers. The Secretariates of Agriculture and Commerce and Industry must agree on the prices guaranteed under the program. Receiving, storing, and handling operations are coordinated with the Government warehousing corporation, ANDSA (Almacenes Nacionales de Deposito, S.A.). In recent years, CONASUPO has cooperated with the Secretariate of Water Resources to discourage production of price-supported, irrigation-intensive crops. Further, while CONASUPO sells some of its stocks in open-market operations nationally or at world prices, an increasing proportion of Government purchases have been guided by the demands of CONDISUPO, a sister agency selling food and soft goods at retail prices to low-income rural families.

The guaranteed prices usually are set in advance of the planting season. Price levels are based on production cost estimates and the desired levels of income support. Prices are changed infrequently (about every 2 years). In general, a single national price, above world market levels, applies to all producers for a stated quality and variety of each crop. For 1966, representative guaranteed prices for corn, wheat, beans, and rice were 940, 800, 1,750, and 900 Mexican pesos per metric ton, respectively *(14,* p. 12). The corn and wheat prices correspond to US$1.91 and US$1.74 per bushel. On the average, however, only about one-eighth of the corn, bean, and rice crops and slightly over two-thirds of the wheat crop came under the support program after 1960, largely because of the high quality standards set for Government purchases, equilibrium local market prices higher than nationally guaranteed prices, and an inadequate number of certified purchasing stations. *(14,* pp. 14-17).

Research

Agricultural research in Mexico is largely synonymous with seed improvement. From 1943 through 1960, the Rockefeller Foundation supported research, in cooperation with the Secretariate of Agriculture, to improve the quality of seeds of the subsistence crops—mainly corn, wheat, and beans. The program scored some notable successes. In 1947, the first improved varieties of corn were given to the Corn Commission for seed production on a commercial scale. By 1954, selected varieties, synthetics, and hybrids were tested and available for most of Mexico's major producing areas. The wheat program was inaugurated in 1943, and in 1948 the first rust-resistant varieties were distributed to Mexican farmers. By 1951, new varieties were sown on about 70 percent of all wheat acreage *(42,* p. 85).

In 1961, responsibility for all work was transferred to the National Institute of Agricultural Research (INIA) with an annual budget of US$2 million provided by the Mexican Government. In 1963, a major achievement was the development of a semi-dwarf wheat, a cross between Japanese and Mexican varieties. This wheat resists lodging under irrigation and heavy applications of fertilizers and thus provides high yields. Mexican dwarf wheats have also been adopted in other developing countries with highly favorable results.

In addition to these successes, the research program has had an important impact on the number and training level of Mexican agronomists. During 1944-60, some 550 Mexicans were commissioned by the Secretariate of Agriculture to work with the Rockefeller Foundation. Over 250 fellowships were granted 155 Mexicans, 52 of whom received Ph.D.'s. When the Rockefeller support ended, these Mexican scientists were able to carry on the research program independently.

Farm use of the improved seeds in Mexico has been, however, somewhat less impressive than the laboratory and educational achievements. In 1965, only about 10 percent of all corn land was planted with improved varieties.[7] Eighty percent of Mexican wheat is planted to improved seeds. However, the crop accounts for only 7 percent of the value of Mexico's crop production.

Agricultural Credit

A system of private and public credit institutions in Mexican agriculture has worked closely with Government fertilizer, seed, irrigation, price support, and other programs. Five official banks provide over 90 percent of the agricultural credit supplied by the public sector. Two of them, organized in 1926, do approximately one-half the lending of this group. BANGRICOLA (Banco de Credito Agricola) provides credit to private farmers and BANJIDAL (Banco de Credito Ejidal) serves the ejidatario. Both banks make commercial loans of 6 months or less for production and/or personal uses, short-term crop loans, and longer term, 8- to 20-year loans for purchases of machinery, livestock, work animals, and land expansion and improvement. Short-term crop loans account for two-thirds of all credit outstanding from the two banks. The value of these loans quadrupled in the 1940's and again in the 1950's. This trend in credit expansion appears to be continuing.

Until the late 1950's the value of short-term credit granted farmers by BANGRICOLA and BANJIDAL exceeded similar credit from private credit institutions. More recently, however, the reverse has been true. Private deposit banks now provide about twice as much credit, even though their interest rates generally are higher than the 9- to 12-percent annual rates quoted by Government banks. This change is primarily the result of establishment of the FONDO (Fondo de Garantia para la Agricultura) in 1955 to make agriculture more attractive to the commercial banking sector. The FONDO serves in an advisory capacity to the private banks, provides them the services of its technical staff, insures their agricultural loans, and provides technical assistance to farmers. Since 1962, the Alliance for Progress has granted Mexico two loans of US$20 million each. The FONDO, operating on behalf of the Central Bank (Banco de Mexico, S.A.), has functioned as an intermediary in dispersing these funds through private banking channels to Mexican farmers.

The combined resources of all the above institutions provided agriculture with US$496 million of short-term credit in 1966, representing 15 percent of the value of crop production. Corresponding figures for 1940 and 1950 were 7 and 12 percent.

Education

Public schooling in Mexico is free, secular, and compulsory for children 6-14 years old. The full school program includes 8 years of primary education, 3 of secondary, 2 of college preparatory or vocational, and 4-5 years of university ("professional"). In 1967, about one-fifth of the 6- to 14-year olds attended primary school, while only 2 percent of the older student-age population enrolled in secondary and higher levels of schooling *(33)*.

Mexico has made some special efforts and achieved important gains in rural schooling.[8] In 1922, President Obregon inaugurated a rural education program with the appointment of "missionary teachers." A missionary teacher was an extension agent, an agronomist, a public health technician, and a school teacher. Later, rural "cultural missions" were sent into farming communities. By 1924, these two programs, together with the small number of operational "rural primary" schools, had enrolled 63,000 primary students out of a rural population of approximately 10 million. As of 1960,

[7] At the time this report was prepared, the last official Mexican report (for 1960) showed a figure of 4.7 percent *(34)*.

[8] The "adequacy" of schooling in urban sectors is not discussed directly here. It has been analyzed in *(4)*.

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rural primary schools had enrolled over 2 million students out of a rural population of 13.8 million, of whom 4.9 million were 6-14 years old *(35)*.

Despite this achievement, there is ample evidence that rural schooling is still not on a par with education in the urban sector. Three quarters of urban school-age children currently enter primary schools, yet only about half in the same age group enter schools in rural areas. In addition, dropout rates are much higher among rural students. Eight percent of the entering rural students complete the third year of instruction, while 50 percent of urban primary students finish 3 years *(28)*.

Almost half (48 percent) of the rural population over 14 years old is illiterate, while the comparable figure in urban areas is 21 percent *(35)*. A serious result has been an apparent shortage of people with agricultural backgrounds and more than a primary education to take advanced training for vocational agriculture, extension, and research activities. Central schools of agriculture were established in the 1920's to develop teachers of vocational education. However, enrollment has been small and the annual number of graduates in the mid-1960's did not exceed 800. Agricultural extension in Mexico likewise dates from the 1920's. Yet, in 1950 there were fewer than 40 technicians on the federal extension field staff. The number has been increased recently, however, to about 200 nonadministrative people. At the professional level of agricultural education, only 3,121 degrees were granted by Mexico's seven schools of agriculture between 1854, when the first agricultural college was established, and 1965. In 1965, these schools produced about 250 graduates.

Mexico has attempted to bridge gaps in rural education over the shortrun by a series of "ad hoc" programs. One of these is the Campaign Against Illiteracy. Mexicans who can read and write are urged through advertising media to teach others not possessing these skills. Also, there are "rural youth clubs" with fairly large memberships, and each year the field experiment stations of the National Institute of Agricultural Research conduct "Demonstration Days" for farmers. However, none of these programs are really capable of coping adequately with the problem of educating Mexican rural youth. The matter of education in rural areas continues to represent an exception to an otherwise commendable tradition of accomplishments in agriculture.

THE MEXICAN APPROACH

Mexico's agricultural development effort has achieved many of its objectives. An important reason for this is the "Mexican Way" of handling policies.

One significant aspect of the Mexican approach is a strong motivation. There is a "will" to develop agriculture and improve rural living conditions. This will is strengthened by a major moral and political momentum stemming from the Revolution of 1910. Whetten, in his sociological treatment of rural Mexico, makes clear the nature of the revolutionary movement:

> One cannot study rural Mexico without running into the Mexican Revolution. It is encountered on every hand. It is spelled with a capital R and is regarded as a process which began in 1910. It is still going on. The first 10 years were devoted largely to armed conflict or civil war. Since 1920 the Revolution has encompassed policies and programs designed to bring about the alleged ideals for which the armed conflict was supposedly fought. These are not stated precisely but appear to include such programs as land for the landless, books and schools for the illiterate, individual freedom from tyranny and oppression, and democracy in Government (*47*, p. viii).

Another significant, and positive, aspect of the Mexican approach is that the Government has not constructed formal, comprehensive, and fully integrated agricultural development plans. Recognizing that statistics were unavailable, that there were not enough technicians, and that organizational procedures were not highly sophisticated, Mexican officials used a rough and ready, piecemeal approach to agricultural development. As a result, specific programs are uncommonly flexible.

A third major element of the Mexican Way is the substantial investment of public funds and other resources in agriculture over a long time. Each year between 1935 and 1958, Mexico channeled 13 to 22 percent of all Government investment into agricultural development programs *(16*, p. 12). Commitments to agriculture have not been compromised by the also urgent demands for rapid industrialization.

A fourth feature of the Mexican approach has been a high concentration of Government resources on a limited number of programs, principally irrigation. During 1935-65, more than two-thirds of Mexico's public investment in agriculture and rural development went into new irrigation projects. Although such programs as research, extension, rural education, price support, and agricultural credit were not neglected, they have constituted a small share of the total development effort in agriculture. An enviable "batting average" of projects completed in relation to projects planned reflects this concentration of effort.

Finally, Mexico has not taken measures to hold down food and other farm product prices to combat inflationary pressures resulting from large development expenditures *(18)*. Essential economic incentives to farmers were maintained on all products, with the possible exception of milk.

III.—THE DEVELOPMENT RECORD, 1940-65

This chapter examines the expansion that occurred during 1940-65 in Mexico's gross farm output, food consumption and net foreign trade in agricultural products. During the period, growth in agricultural output substantially exceeded increases in population (fig. 5). Production, consumption, and agricultural trade are focal points because they are the most all-inclusive economic indicators of the agricultural development record after 1940 (fig. 6). Not only do they provide a complete picture of what happened, but they form a basis for analyzing the significant factors that explain why it happened.

AGGREGATE PRODUCTION

Total farm output in Mexico rose sharply during World War II and has continued to increase at high, but slightly lower, rates since then (table 4). The record of performance in the crop sector has been better and more consistent than that in the dairy and meat sectors. From 1940 through 1953, the total output of 37 principal crops increased 5.7 percent a year and continued to increase 4.7 percent annually during 1954-65. Nine crops (corn, cotton, coffee, beans, wheat, henequen, sugarcane, tomatoes, and rice) accounted for 80 percent

Table 4.—Agricultural production in Mexico, by value of components, 1940-65

Year	Crops[1]	Livestock products			Total
		Meat[2]	Dairy[3]	Subtotal	
Value of production	*Million 1960 pesos*				
1940	4,318	2,417	1,386	3,803	8,121
1941	4,277	1,942	1,867	3,809	8,086
1942	4,967	2,604	2,438	5,042	10,009
1943	5,555	2,393	2,841	5,234	10,789
1944	5,328	2,123	2,671	4,794	10,122
1945	5,819	2,444	2,654	5,098	10,917
1946	5,765	2,628	2,260	4,888	10,653
1947	6,069	2,276	2,288	4,564	10,633
1948	6,608	3,149	2,620	5,769	12,377
1949	7,276	2,991	2,793	5,784	13,060
1950	8,042	2,643	3,181	5,824	13,866
1951	8,563	2,505	3,610	6,115	14,678
1952	8,718	2,682	3,547	6,229	14,947
1953	8,433	2,546	3,877	6,423	14,856
1954	9,100	2,630	4,381	7,011	16,111
1955	10,382	2,740	4,591	7,331	17,713
1956	11,249	3,277	4,725	8,002	19,251
1957	11,138	3,271	5,164	8,435	19,573
1958	11,677	3,778	4,819	8,597	20,274
1959	12,790	3,600	4,673	8,273	21,063
1960	12,267	3,660	4,268	7,928	20,195
1961	12,767	4,181	4,239	8,420	21,187
1962	13,771	4,395	4,403	8,798	22,569
1963	14,125	4,570	4,496	9,066	23,191
1964	15,775	4,441	4,781	9,222	24,997
1965	17,000	4,818	4,649	9,467	26,467
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Compound rate of change[4]					
1940-53	5.7	[5]1.5	5.5	3.5	4.7
1954-65	4.7	5.3	0.0	2.2	3.7
1940-65	5.3	3.0	4.2	3.5	4.6

[1] 37 principal crops. [2] Includes only meat of cattle, pigs, sheep, and goats. Excludes inventory changes. [3] Excludes goat's milk and eggs. [4] Calculated from regressions of the log of the growth variable on an index of time. [5] Not statistically different from zero at $t_{0.025}$.

Source: Data and procedures discussed in app. B.

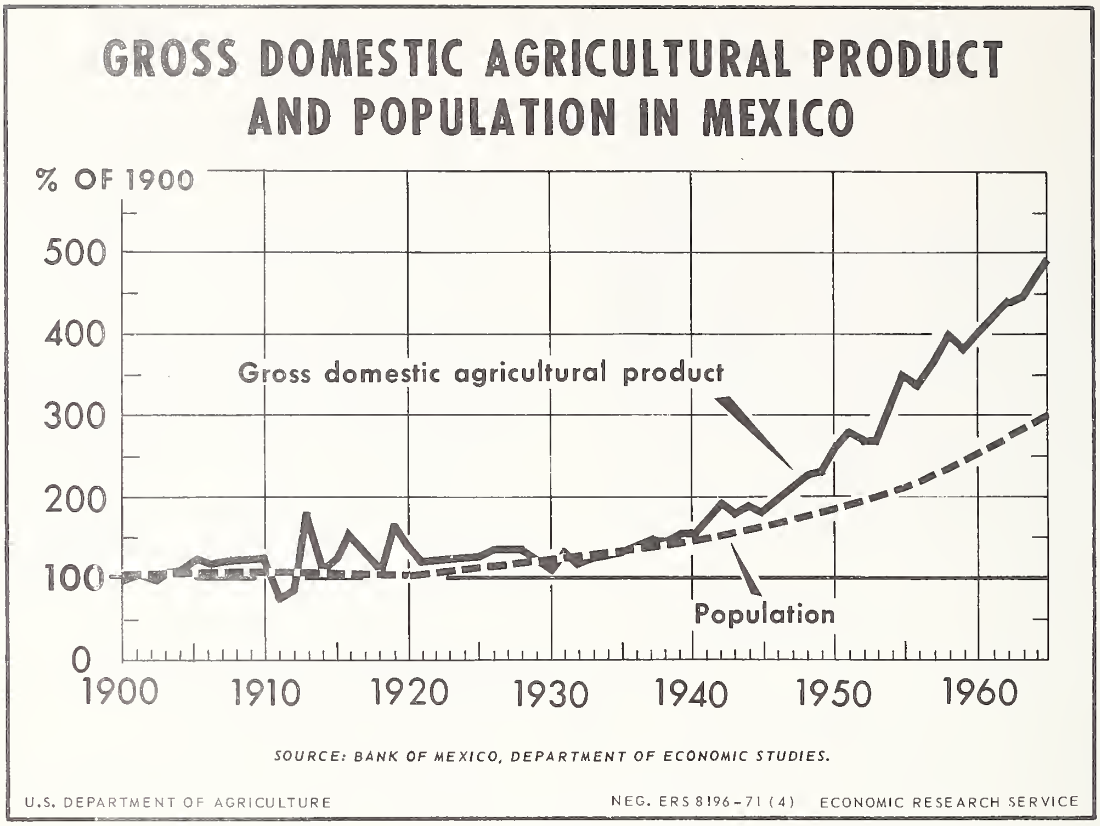

Figure 5

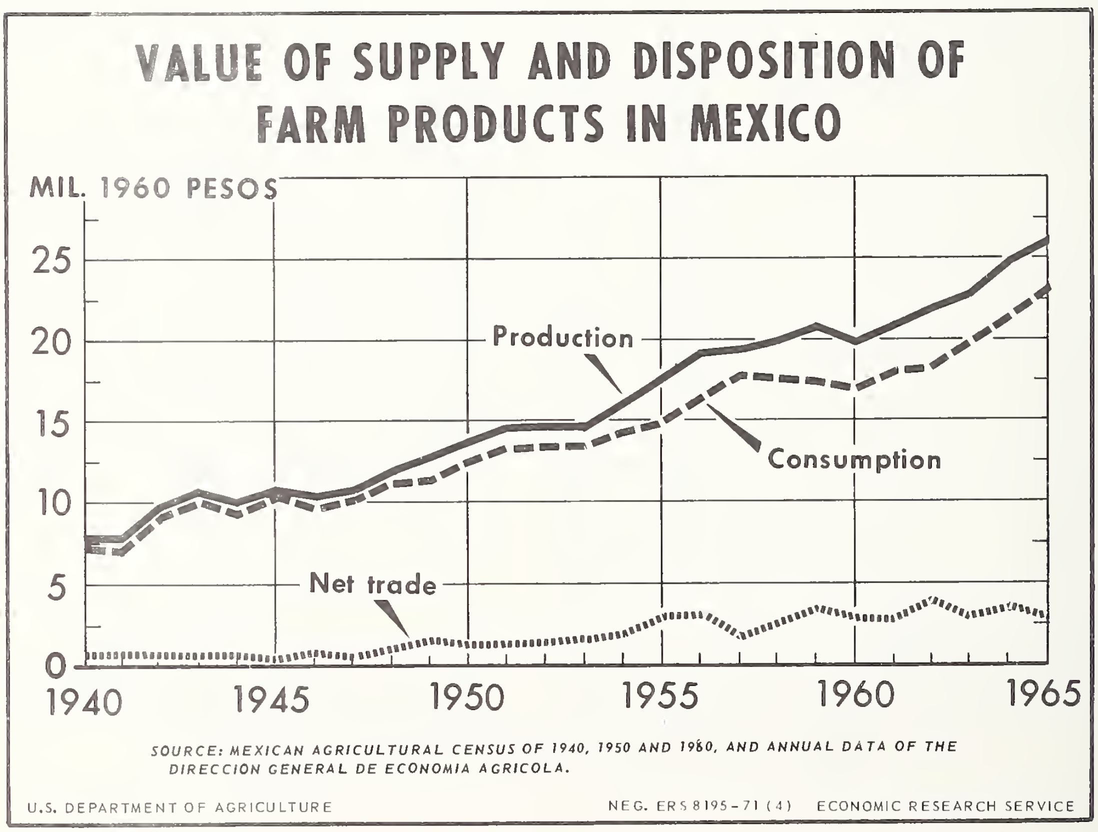

Figure 6

or more of the post-1940 increase in crop production, with corn (because of its importance) and cotton (because of its high growth) making the major contributions.[9]

Aggregate output of dairy products also increased sharply during 1940-53, but production remained almost unchanged during 1954-65. In contrast, production of meat—excluding poultry—rose moderately in the earlier period, but increased 5.3 percent a year during 1954-65.

FOOD CONSUMPTION

Apparent consumption of food in Mexico increased about 4.1 percent a year during 1940-65. Per capita consumption rose 1.1 percent annually (table 5), while population increased about 3.0 percent annually. Substantially higher rates of per capita food consumption growth were recorded in 1940-53 (1.9 percent a year) than in 1954-65 (1.2 percent a year). Per capita food consumption gains prior to 1953 were accounted for by increased use of crop and dairy products. Since 1953, per capita consumption of dairy products has fallen, while consumption of food crops has continued to rise. Throughout 1940-65, per capita consumption of meats—excluding poultry—fluctuated from year to year without significant trend.

These gains in per capita consumption have resulted in major improvements in the average Mexican's diet. From 1934-38 through 1960, daily per capita caloric intake rose nearly 50 percent (table 6), which suggests that such intake may now be close to the average of 3,000 calories enjoyed by persons in high-income countries. Daily per capita protein intake in Mexico rose from 53 grams in 1934-38 to 67 grams in 1960. All of this increase came from vegetable proteins, since per capita consumption of meat remained stable.

Mexicans have been able to improve both the quality and quantity of per capita food consumption since 1940, and yet spend proportionately less of their total budget on food. In 1938, the average Mexican family allocated over one-half its total expenditures to food and beverage items, but by 1963, the proportion was about 40 percent (table 7).

Table 5.—Per capita consumption of food products, Mexico, by value, 1940-65

Year	Food products			Total
	Crop[1]	Meat[2]	Dairy[3]	
	1960 pesos	*1960 pesos*	*1960 pesos*	*1960 pesos*
1940	207	109	71	387
1941	197	79	93	370
1942	228	109	119	457
1943	250	99	135	483
1944	226	90	124	439
1945	258	98	120	476
1946	234	102	101	437
1947	233	96	100	430
1948	254	111	110	475
1949	253	101	114	468
1950	273	96	126	495
1951	285	87	139	512
1952	284	88	134	506
1953	256	85	143	483
1954	257	89	156	502
1955	265	86	159	510
1956	280	105	160	544
1957	308	96	169	573
1958	307	102	154	562
1959	297	97	145	538
1960	280	93	126	496
1961	288	100	121	509
1962	281	98	124	503
1963	320	102	124	526
1964	326	100	126	538
1965	331	103	116	566
	Percent	*Percent*	*Percent*	*Percent*
Compound rate of change:				
1940-53	2.2	[4] -0.7	2.9	1.7
1954-65	1.6	[4] 1.0	-3.3	[4] 0.2
1940-65	1.5	[4] 0.0	1.5	1.1

[1] Refers to 37 principal crops and includes consumption for intermediate uses. [2] Includes only meat of cattle, pigs, sheep, and goats. [3] Excludes goat's milk and all poultry products. [4] Not statistically different from zero at $t_{0.025}$.

Source: Data and procedures discussed in app. B.

Table 6.—Daily per capita caloric and protein consumption, Mexico, selected years, 1934-60

Period	Calories	Proteins		
		Total	Animal	Vegetable
	Units	*Grams*	*Grams*	*Grams*
1934-38	1,800	53	18	35
1948-52	2,220	58	16	42
1957-59	2,440	68	20	40
1960	2,654	67	19	48

Source: *(46,* p. 74).

Table 7.—Distribution of family consumption expenditures, Mexico, 1938 and 1963

Item	1938[1]	1963[2]
	Percent	*Percent*
Food[3]	54.9	40.5
Clothing	8.2	13.5
Housing	9.4	16.3
Other	27.5	29.7
Total	100.0	100.0

[1] *(33),* chap. XV for Mexico City. [2] *(46,* p. 34) for urban population. [3] Food and some beverage items.

[9] Production, yield, and land area harvested data are shown in app. B.

Income

Increases in per capita food use in Mexico are associated with a significant rise in per capita incomes. During 1940-65, gross domestic product (GDP) increased 6.1 percent a year, or roughly 3.1 percent a year per capita (table 8). Highest rates of growth occurred in the 1940's. In the early 1950's, expansion abated and high growth was not restored in subsequent years. Reduction in the growth rates of the crop sector of agriculture and the transportation and communications sectors of industry were the principal causes of this decline (table 8).

In 1963, a Bank of Mexico survey *(46)* of 5,070 family household units yielded two conclusions relevant to the effects of per capita income increases on apparent food consumption. One was that the income elasticity of demand for food was about 0.35. The other was that urban populations had lower elasticities than did rural populations. Since urban population increased from 35 to 53 percent of total population during 1940-65, the estimated coefficient of 0.35 represents a historically low value for Mexico.

The implication is that per capita food consumption increased at least 1.1 percentage points per year after 1940 as a result of the 3.1-percent increase in per capita income, with the contribution of income growth to food demand being greater in 1940-53 (at least 1.5 percent per year) than in 1954-65 (about 0.7 percent per year).

Food Prices

Wholesale prices of unprocessed foods relative to wholesale prices of nonfood and processed food products trended down during both 1940-53 and 1954-65, with the fastest rate of decrease occurring in the latter period (table 9). Crop items were the dominant force behind this trend—their relative wholesale price decreased at an average annual rate of 0.8 percent after 1940. Prices of animal products showed an opposite trend over the whole period, rising most rapidly after the mid-1950's. As a result, prices of animal products relative to prices of crop items increased at an average annual rate of 2.0 percent during 1940-53, and by as much as 5.4 percent annually after 1953.

With population and per capita income increases accounting for almost all of the 4.1-percent annual increase in apparent food consumption, the net effect of prices on demand was probably small over the post-1940 period.

However, changes in prices of crop products relative to prices of livestock products reflected the larger expansion in crop production and guided family budget allocations between categories of food expenditure. Rising relative prices of animal products are consistent with earlier evidence showing no significant increases in per capita meat consumption and progressive reliance upon vegetable products as a source of protein. The relative increase in livestock prices is also of interest in

Table 8.—Gross domestic product, by industrial sector, Mexico, 1900-10 and 1921-65

Industrial sector	Compound annual rates of growth					
	1900-10	1921-30	1930-40	1940-55	1955-65	1940-65
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Crop	3.7	-1.4	2.4	5.9	3.1	5.2
Livestock	1.1	0.2	3.8	3.0	4.1	3.7
Mining	5.4	8.9	1.2	0.0	1.4	1.4
Petroleum	34.5	-14.9	3.8	6.6	7.6	7.0
Manufacturing	2.9	5.2	6.7	6.6	7.4	7.0
Transportation and communication	2.8	6.4	3.4	7.1	3.3	6.1
Other	3.3	1.4	3.8	3.5	2.7	3.1
Total GDP	3.3	1.4	3.6	6.4	5.7	6.1
Population	1.1	-0.6	1.8	2.7	3.6	3.0
Per capita GDP	2.2	2.0	1.8	3.7	1.9	3.1

Industrial sector	Shares of GDP				Contribution to 1940-65 GDP growth
	1900	1921	1940	1965	
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Crop	20.1	17.9	15.4	11.4	10.4
Livestock	9.2	7.4	11.5	5.3	3.8
Mining	5.5	4.2	6.2	1.7	0.6
Petroleum	nil	6.9	3.3	3.2	3.2
Manufacturing	12.5	10.4	20.0	25.3	26.6
Transportation and communication	2.4	2.8	5.0	4.3	4.1
Other	50.3	50.4	38.6	48.8	51.3
Total GDP	100.0	100.0	100.0	100.0	100.0

Source: From data of the Bank of Mexico, Department of Economic Studies, and *(6, 30)*.

Table 9.—Compound rates of change in wholesale prices, selected commodity aggregates, Mexico, 1940-65

Commodity aggregate	1940-53	1954-65	1940-65
	Percent	*Percent*	*Percent*
Crop items[1]	10.2	1.3	7.5
Animal products[2]	12.3	6.7	9.6
Unprocessed foods	11.1	3.8	8.4
Processed foods and nonfood items	11.7	5.0	8.3
Composite index (216 items)	11.4	4.4	8.3
Relative food prices[3]	- 0.6	-1.2	0.1
Relative crop prices[4]	- 1.5	-3.7	-0.8
Relative animal product prices[5]	0.6	1.7	1.3

[1] Fruit, vegetables, and cereals only. [2] Includes meat and milk products. [3] Line 3 minus line 4. [4] Line 1 minus line 4. [5] Line 2 minus line 4.

Source: App. table B-7.

light of the different trends of per capita consumption before and after 1953. During 1940-53, income and population growth accounted annually for 4.2 percent of the 4.6-percent annual increase in aggregate food consumption, implying that the net effect of price movements was to increase the demand for food. Conversely, prices after 1953 decreased aggregate demand by about -0.7 percent a year. These different intradecade net price effects, compared with actual changes in prices of livestock and crop products, lead to two conclusions: price substitution between livestock and crop categories of food consumption is low and the direct price elasticity of demand for crop items is lower than for animal products.

FOREIGN TRADE

Mexico's foreign trade has benefited directly from the growth of its farm sector. During 1940-65, exports of agricultural products ranked second only to raw material exports as a source of foreign exchange earnings (table 10). Principal items exported by the farm sector were cotton, coffee, henequen (Mexican sisal), tomatoes, and live cattle. The United States was Mexico's primary customer for these products. In 1965, the United States purchased about two-thirds of Mexico's farm commodity exports, with coffee, cattle and meat, sugar, fruits, and vegetables accounting for 80 percent of the total *(20)*. Mexico's food imports, on the other hand, constituted only a minor share of the value of all imported products (table 11). Items imported for use in agricultural production have represented a small share of total imports.

Thus, foreign trade in agricultural products consistently yielded an export surplus during 1940-65. The surplus increased dramatically (8.5 percent per year) during 1940-53, but expanded at slower rates (1.8 percent per year) during 1954-65—primarily because of a decline in the growth of crop exports and continued increases in imports of dairy products (table 12).

The difference in the trend of crop exports was largely due to changes in Mexico's fiber output, particularly cotton. During 1945-55, cotton production increased 421 percent and exports rose 712 percent *(19, p. 40)*. Ginned and equivalent manufactured cotton accounted for one-quarter of the value of crop export sales. But since 1956, both cotton production and cotton exports have remained about constant because of falling relative prices *(19)*. This trend has not yet shown signs of reversing itself. Partly as a consequence of this pattern in fiber exports, the composition of crop items entering foreign trade has shifted. Since the mid-1950's, increasing exports of finished foodstuffs have replaced traditional items not subjected to processing.

In contrast to crop exports, cattle and meat product sales fluctuated without trend during 1940-53, but increased in 1954-65, reflecting higher production levels.

Dairy product exports made no contribution to the favorable trade balance of agricultural products during 1940-65. Except for small exports of butter and cheese in the early 1940's, Mexico's trade in dairy products has been dominated by rapid and steady rates of increase in imports. Purchases of dry, condensed, and evaporated milk products accounted for the largest proportion of the increases.

Table 10.—Percentage distribution of Mexico's exports, by principal trade categories, selected years, 1940-65

Category	1940	1945	1950	1955	1960	1965
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Food products	9.7	20.3	23.3	21.3	31.5	39.5
Beverages and tobaccos	0.1	2.4	0.1	0.1	0.2	0.5
Raw materials	16.1	15.0	30.2	33.6	25.8	32.0
Lubricants and related mineral products	9.3	3.2	6.4	7.0	2.3	3.6
Animal and vegetable oils	0.4	1.6	0.8	0.3	0.4	0.2
Chemical products	1.5	3.8	1.0	1.0	2.3	3.9
Fertilizers	nil	nil	nil	nil	nil	nil
Manufactures	24.7	34.5	24.0	19.7	16.4	7.7
Machinery and transportation articles	0.1	0.5	0.6	0.3	1.1	1.5
Agricultural machinery	nil	nil	0.1	nil	0.1	nil
Other items	38.1	18.7	13.7	16.7	19.9	11.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: *(32)*. See vol. for 1961, pp. 776-790, for detailed definitions of each trade category.

Table 11.—Percentage distribution of Mexico's imports, by principal trade categories, selected years, 1940-65

Category	1940	1945	1950	1955	1960	1965
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Food products	3.5	13.9	8.8	3.7	4.1	3.8
Beverages and tobaccos	1.1	1.2	1.1	0.5	0.7	0.6
Raw materials	17.3	13.8	7.8	9.4	7.5	4.5
Lubricants and related mineral products	3.2	2.8	4.8	8.6	4.1	2.5
Animal and vegetable oils	1.5	2.6	0.2	0.7	0.2	0.7
Chemical products	12.3	10.2	11.9	13.3	15.6	14.8
Fertilizers	0.4	0.3	0.2	0.9	2.1	0.3
Manufactures	18.6	15.8	18.5	14.4	11.6	20.2
Machinery and transportation articles	30.6	27.2	38.9	42.1	48.9	49.1
Agricultural machinery	1.0	1.1	2.8	4.5	2.2	2.3
Other items	11.7	12.5	8.0	7.3	7.3	3.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: *(32)*. See vol. for 1961, pp. 776-790, for detailed definitions of each trade category.

Table 12.—Selected trade data, Mexico, 1940-65

Year	Exports			Imports			Trade balance[4]	Export earnings	
	Crop items[1]	Meat[2]	Dairy items[3]	Crop items[1]	Meat[2]	Dairy items[3]		Agricultural[5]	Total[6]
	Mil. 1960 pesos	*Mil. 1960 pesos*	*Mil. 1960 pesos*	*Mil. 1960 pesos*	*Mil. 1960 pesos*	*Mil. 1960 pesos*	*Mil. 1960 pesos*	*Mil. U.S. dollars*	*Mil. U.S. dollars*
1940	293	270	1	40	1	7	518	19.5	119.8
1941	467	351	2	164		9	649	31.9	123.1
1942	374	347	2	132		8	585	40.2	150.2
1943	541	306	1	283		5	562	59.0	215.1
1944	941	188	2	525	10	11	589	63.5	201.7
1945	399	266	3	335	9	22	308	57.7	235.1
1946	676	289	1	265	1	47	667	76.0	279.6
1947	827			271		71	507	114.2	262.6
1948	716	449		277		59	847	81.5	399.2
1949	1,175	454		242		44	1,357	117.0	352.7
1950	1,390	169		399		49	1,127	233.9	493.4
1951	1,455	207		425		61	1,194	278.2	591.5
1952	1,706	298		664		71	1,291	309.5	625.3
1953	1,886	165		591	1	89	1,398	298.7	559.1
1954	2,014	87		226		38	1,849	323.7	615.8
1955	2,671	212		45		39	2,811	394.8	738.5
1956	3,001	106		205		75	2,851	411.7	807.2
1957	2,202	276		644		78	1,780	336.9	706.1
1958	2,523	512		674		90	2,299	377.4	709.1
1959	3,131	400		168	1	107	2,289	373.2	723.0
1960	2,775	411		177		121	2,926	352.9	738.7
1961	2,533	570		182		131	2,830	343.4	803.5
1962	3,405	727		165		233	3,806	426.4	899.5
1963	2,961	636		489		277	2,917	380.9	935.9
1964	3,415	427		183	1	257	3,481	434.4	1,023.5
1965	2,788	545		247	8	151	2,973	504.4	1,110.7
	Percent	*Percent*		*Percent*		*Percent*	*Percent*		
Compound rate of change:									
1940-53	13.3	0.0		12.9		21.9	8.3		
1954-65	3.5	17.6		*3.6		20.1	*3.9		
1940-65	10.1	*4.3		*1.4		13.7	9.1		

Note: *Estimated $t < t_{0.025}$. [1] 37 principal crops. [2] Includes only meat of cattle, pigs, sheep, and goats. [3] Excludes goat's milk and all poultry products. [4] Exports less imports. [5] From Depto. de Estudios Economicos, Banco de Mexico, S.A.; relates only to "principal" crop and livestock items. [6] Principal export items, from Depto. de Estudios Economicos, Banco de Mexico, S.A.

Source: Data and procedures discussed in app. B.

IV.—PHYSICAL SOURCES OF GROWTH

Mexico's agricultural production grew rapidly during 1940-65 as a result of changes in the quantity and quality of productive resources. These resources include physical inputs as well as social inputs such as land reform and irrigation development. This chapter makes empirical estimates of these inputs and relates them to output to obtain estimates of productivity.

A total factor productivity approach identifies input contributions and patterns for all of Mexican agriculture during 1940-65. Input changes during 1940-65 and 1960 input shares are used to measure changes in the productivity of given inputs. In addition, a comparison is made with a more detailed cross-sectional productivity calculation. The latter uses 1960 county census data in a Cobb-Douglas production function which incorporates the influence of land reform and irrigation upon productivity.

TOTAL FACTOR PRODUCTIVITY

Compound rates of change in resource use were calculated from a time series of reasonably detailed inputs adjusted for changes in "quality." The inputs were grouped into six categories: purchased inputs (noncapital, including fertilizers, insecticides, seeds, and irrigation water); family labor; hired labor; land; livestock capital; and power and implements.

These compound rates of change in individual inputs may be added to obtain a measure of change in total input, which in turn can be related to total output. In this way, output increases may be attributed to (1) increases in total input and (2) increases in individual inputs. Results are shown in table 13: 1960 input shares have been multiplied by the compound rate of change in individual inputs—for 1940-53, 1954-65, and 1940-65—to determine the compound rate of change in the contribution of each input. The differences between the growth rate in total output and total input is the total factor productivity increase.

For Mexican agriculture, total factor productivity increased at an average annual rate of 2.0 percent during the 25-year period 1940-65, with inputs rising 2.6 percent annually and output, 4.6 percent annually. This is a strong productivity gain. A similarly derived estimate for U.S. agriculture during the same period shows that total factor productivity increased an average of 1.5 percent annually *(44,* p. 17). Total U.S. inputs showed only a small rise; output per person showed a large rise, however, because substitution of purchased inputs for human labor resulted in fewer workers over the years. In Mexico, all major inputs increased. However, purchased inputs and power and implements expanded more rapidly than labor.

In Mexico, all labor inputs increased about 1.5 percent annually, with hired labor showing the highest increase (4.8 percent) and farmers on large farms and ejidatarios showing smaller increases (2.2 and 1.3

Table 13.—Agricultural output and input, and total factor productivity, Mexico, 1940-65

Input	1960 input share[1]	Compound rates of change in inputs			Compound rates of change in the input's contribution to gross farm output		
		1940-53	1954-65	1940-65	1940-53	1954-65	1940-65
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Purchased inputs	7.1	6.5	9.2	8.4	0.5	0.7	0.6
Hired labor	7.8	8.6	1.2	4.8	.7	.1	.4
Family labor	30.1	4.0	2.3	3.3	.3	.1	.2
All labor	37.9	12.6	3.5	8.1	1.0	.2	.6
Land	29.1	2.2	1.2	2.0	.6	.3	.6
Livestock capital	19.0	1.9	1.9	2.4	.4	.4	.5
Power and implements	6.9	6.7	2.4	4.9	.5	.2	.3
Total input	100				3.0	1.8	2.6
Total factor productivity					1.7	1.9	2.0
Total output					4.7	3.7	4.6

[1] Percentage distribution of the cost of inputs in 1960. The estimates of input shares are shown in App. A.

Source: *(21).*

percent, respectively). Although substitution of purchased inputs for labor was not clearly indicated, output per man did increase 3 percent a year.

As mentioned above, rapid annual increases occurred in purchased inputs (8.4 percent) and in power and implements (4.9 percent). Land area farmed increased 2.0 percent annually (output per hectare rose at a faster rate, 2.6 percent). Agricultural output rose faster in the early part of the period (1940-53) than in the later years (1954-65). This is attributable to a decline in the annual input growth rate—from 3 percent in 1940-53 to 1.8 percent in 1954-65. Growth in purchased inputs was substantially higher in the later period, but for power and implements and hired labor, growth was higher in the earlier period. Total factor productivity rose an average of 1.9 percent annually during 1954-65, compared with 1.7 percent during 1940-53.

CROSS-SECTION COMPARISONS

The above calculations show that the gain in total factor productivity accounted for over half the rise in production. This high total factor productivity gain could have been, in part, a result of 1960 factor shares undervaluing certain inputs. For example, some nontraditional inputs (such as purchased inputs—particularly fertilizer and irrigation water—and capital inputs) might have been more productive than their actual costs implied.

In the next section, productivity is viewed cross sectionally. Provisions were made to consider the effects of tenure and irrigation on productivity.

Production Function Estimates

A cross section study of the structure of Mexican agricultural production and productivity was based on unpublished county-level summaries of the 1960 Mexican Agricultural Census. Effects of land reform and irrigation policies on input productivity were incorporated specifically by estimating aggregate production functions for four production groups: (1) the private sector outside SRH irrigation districts, (2) the ejido sector outside SRH irrigation districts, (3) the private sector inside SRH irrigation districts, and (4) the ejido sector inside SRH irrigation districts.

Regression results are summarized in table 15. They indicate that purchased inputs were more productive than indicated by the calculation based on 1960 factor shares. A similar conclusion applies to hired labor, livestock capital, and power and implements. On the other hand, family labor and land were less productive. As expected, the estimated productivity of purchased inputs was higher inside than outside the SRH irrigation districts. Also, family labor productivity was noticeably lower in the ejido than in the private sector.

These results point to basic explanations for the 2.0-percent annual growth in Mexican agricultural productivity between 1940 and 1960 that was estimated using the factor shares method. When the production function weights are used instead of the 1960 factor shares in calculating input contributions, the total factor productivity increase declines from 2.0 percent to 0.4 percent (table 14). A comparison of individual input contributions estimated by the two methods reveals two major sources of differences:

Under the production function estimates, (1) the productivity of purchased inputs and power and implements is higher; and (2) smaller weights were assigned family labor, principally because of the low productivity of the input in the ejido sector.

Table 14.—Compound rates of change in the contribution of inputs to gross farm output, based on cross-section production function weights, Mexico, 1940-65[1]

Input	1940-53	1954-65	1940-65
	Percent	*Percent*	*Percent*
Purchased inputs	[2] 0.7	[2] 1.6	[2] 1.2
Hired labor	1.7	0.3	1.0
Family labor	0.4	nil.	0.2
All labor	2.3	0.2	1.3
Land	0.5	0.5	0.5
Livestock capital	0.5	0.5	0.7
Power and implements	0.8	0.3	0.6
Total input	4.7	3.3	4.2
"Residual," total factor productivity	0.0	0.6	0.4
Total output	4.7	3.7	4.6

[1] Except where noted, this is defined as the compound growth rate of an input times the "aggregate" input weight derived from regression 4 of each production function shown in the last column of table A-6. [2] The input weight used for 1940-53 assumed no irrigation. For 1954-65, it was assumed that this category of inputs would increase at no more than 4.0 percent a year on unirrigated land, given observed price movements. Since total use of purchased inputs increased 9.2 percent and SRH districts used 37.8 percent of the value of purchased inputs in 1960 (according to the county-level Census data), a 17.8-percent increase in purchased inputs inside SRH districts was implied. Weighting each of these rates by the appropriate product share aggregate input elasticities from regression 4 yielded the annual 1.6-percent "contribution"; that is, 0.074 (4.0) + 0.072 (17.8) =1.6, where 0.074 = 0.102 (0.433) + 0.118 (0.252) and 0.072 = 0.287 (0.192) ÷ 0.136 (0.123). For the whole period 1940-65, it was assumed that purchased inputs changed proportionately in all groups. As it turned out, the estimated contribution on this assumption is identically equal to that which would have resulted from assuming that this category increased 6.5 percent for 13 years and 17.8 percent for 12 years inside SRH and 6.5 percent for 13 years and 4.0 percent for 12 years outside SRH.

For the intraperiods 1940-53 and 1954-65, the method of calculating the contribution of purchased inputs, using production function weights, was modified slightly to incorporate information not available for estimates derived from factor shares. This input index explains all the 4.7-percent annual increase in output during earlier years. For later years, however, a small residual increase in output per unit of input remains. Reasons for this, as well as other details of the estimates summarized here, are presented in appendix A.

Table 15.—Estimated input weights for a cross-section comparison of agricultural inputs in Mexico, 1940-65

Input	Regression estimates[1]				Weighted regression estimates		Factor share weights[4]
	Private sector outside SRH irrigation district	Ejido sector outside SRH irrigation district	Private sector inside SRH irrigation district	Ejido sector inside SRH irrigation district	Simple average[2]	Product share average[3]	
Purchased inputs	0.102	0.118	0.287	0.137	0.126	0.146	0.071
Family labor	.112	-.121	.195	-.041	.015	.050	.301
(On small, private farms)							(.093)
(On other farms)							(.208)
Hired labor	.237	.154	.065	.041	.175	.159	.078
(On small, private farms)							(.007)
(On other farms)							(.071)
All labor	.349	.033	.260	- - -	.190	.209	.379
Land	.161	.270	.274	.130	.211	.206	.291
Livestock capital	.351	.323	.145	.231	.314	.290	.190
Power and implements	.113	.125	.048	.227	.121	.117	.069

[1] Estimates of input weights were derived from a Cobb-Douglas production function. The specification of the functions is shown in app. A. [2] These are a weighted sum of the individual group coefficients, where the weight for a group equaled its share of the total number of observations in the census data. [3] These are a weighted sum of the individual group coefficients, where the weight for a group equaled its share of gross farm production. The weights for group 1-4 were respectively 0.433, 0.252, 0.192, and 0.123. [4] These were calculated from data shown in app. B.

Group Means

Average values of inputs and output per farm for the four production groups are not available in the published summaries of the Mexican Agricultural Census. This report's calculations for such values are shown in table 16.

The first four rows of the table show larger differences in output per farm between tenure classes than between irrigated and unirrigated regions. Output per farm drops 80 percent from the private to the ejido sector and this differential is constant for comparisons made either inside or outside SRH districts. Output per farm was about 50 percent higher for units located in the SRH districts. Since this size ratio is also similar for ejido and private tenure groups, major policy developments do not appear to have created unusual "interactions" on the output side.

From the county-level census data, the average level of output per farm for the four production groups is estimated to have been US$590. That this figure is low is dramatized by the fact that agricultural output per worker in all of Latin America was earlier shown to average US$558 (see table 1). Since output per farm constitutes a ceiling for output per worker, Mexico's extremely low average product for labor (US$350, table 1), compared with that of other nations in the region, is largely a function of the "scale" of its farms. This small scale is, in turn, an obvious product of the large number of small farms in the land reform, ejido sector.

On the input side, mean levels of use for most inputs move roughly in proportion to group levels of output. There are, however, at least two exceptions worth noting. One is represented by the family labor input. Its relative constancy suggests that the "optimum" scale of use of nonfamily labor inputs is rather similar for the production groups, but that the scale of use of all inputs is variable and dependent on the proportions in which family labor and other inputs are employed. This was confirmed by the production function results.

Table 16.—Group means[1] and related summary statistics from a cross-section comparison of agricultural inputs in Mexico, 1940-65

Group	Number of observations in	Number of farms in	Livestock share in gross farm output	Group means per farm						
				Output	Purchased inputs	Family labor	Hired labor	Land[2]	Livestock capital	Power and implements
		Thousands	*Percent*	*U.S. dollars*	*U.S. dollars*	*Equivalent man-years*	*Equivalent man-years*	*U.S. dollars*	*U.S. dollars*	*U.S. dollars*
(1) Private sector, outside SRH	1,359	376	39.1	1,192	55	2.07	0.36	1,600	208	78
(2) Ejido sector, outside SRH	1,193	1,100	24.1	233	11	1.79	0.02	402	30	17
(3) Private sector, inside SRH	250	79	28.7	1,816	126	1.95	0.52	2,240	198	184
(4) Ejido sector, inside SRH	229	331	16.1	342	22	1.93	0.04	512	24	28
(1&2) Outside SRH districts				555	25	1.93	0.10	840	83	38
(3&4) Inside SRH districts				816	55	1.94	0.14	1,144	72	74
(1&3) Private sector				1,272	63	2.05	0.38	1,688	206	89
(2&4) Ejido sector				247	12	1.81	0.03	417	29	18
Total or average	3,036	1,886	30.5	590	29	1.94	0.11	872	82	43

[1] Geometric means. [2] Stock value.

The other exception relates to the disproportionately higher levels of use of purchased inputs and power and implements for observations inside SRH districts.

UTILIZATION OF INPUTS

Purchased Inputs

An important characteristic of Mexico's agricultural development has been the increased use of purchased inputs. In the classification used here, only noncapital inputs are included; inputs of implements and power are treated separately. Input series were developed for chemical fertilizers, seeds, insecticides, and irrigation water for 1940-65 (table 17 and app. B).[10]

The composite index of purchased inputs rose 6.5

[10] The methods used in compiling and weighting these series are shown in detail in app. B. A brief report of yield responses to purchased inputs, based on Mexican Experiment Station data, is shown in app. A.

Table 17.—Indexes of purchased inputs in Mexican agriculture, 1940-65

Year	Chemical fertilizers[1]	Seeds: Volume[2]	Seeds: Quality[3]	Seeds: Adjusted volume[4]	Insecticides[5]	Irrigation: Private[6]	Irrigation: SRH[7]	Irrigation: Total[8]	Composite purchased input index[9]
1940	4	35	83	29	1	123	2	39	18
1941	5	35	83	29	1	121	3	39	18
1942	4	40	83	33	2	120	5	40	23
1943	5	45	83	37	2	118	6	40	24
1944	4	43	83	36	3	117	6	40	26
1945	6	47	83	39	5	115	7	40	26
1946	5	47	83	39	2	114	9	41	27
1947	10	49	83	41	2	112	10	41	27
1948	6	54	83	45	3	111	11	41	33
1949	7	59	84	49	3	109	12	41	34
1950	8	65	85	55	12	105	14	41	38
1951	13	70	86	60	22	104	19	45	41
1952	17	71	87	62	23	104	23	47	40
1953	21	69	88	61	33	103	25	49	40
1954	25	74	92	68	51	103	37	57	47
1955	36	85	94	80	86	102	44	62	65
1956	54	92	95	87	73	102	52	67	67
1957	51	91	102	93	85	102	48	64	69
1958	65	95	102	97	102	101	59	72	76
1959	80	104	99	103	101	101	60	73	87
1960	100	100	100	100	100	100	100	100	100
1961	104	104	98	102	89	100	111	107	103
1962	105	112	101	113	108	99	132	122	110
1963	127	115	103	118	107	99	115	110	119
1964	158	129	99	128	107	98	142	128	139
1965	160	139	98	136	112	98	140	127	143
	Percent			*Percent*	*Percent*		*Percent*	*Percent*	*Percent*
Compound rate of change:									
1940-53	18.6			6.2	24.4		17.4	1.4	6.5
1954-65	12.2			5.3	4.9		14.3	8.3	9.2
1940-65	17.0			6.4	21.5		17.6	5.3	8.4

[1] A price-weighted index of apparent domestic consumption of N, P, and K. Consumption estimates were obtained from *(49)*. Prices were for 1960 as reported in app. B. [2] Seed use was taken proportional to aggregate crop production. [3] Includes improved varieties of wheat and corn only. The improved seed component of each crop was estimated as production times the proportion used for seed *(46, p. 23)* times an estimate of the percentage sown to improved varieties. Farm prices received for each crop were used to aggregate the estimates and the aggregate was multiplied by 0.60, divided by 1 percent of crop output, and added to 1.0 to obtain the "quality" index. The factor 0.60 reflects an assumption that "improved" seeds are 60 percent more valuable per unit than "criolla" varieties. This is considered to be a generous assumption. In the case of wheat, however, it is supported by Ardito's results *(3)*. The composite index of purchased inputs is reasonably insensitive to this quality adjustment. [4] The index of "volume" times the index of "quality". [5] Data after 1949 are from *(46, p. 104)* updated. An index of insecticide imports was linked to this series for the 1940-49 estimates. [6] For 1960, the Mexican Agricultural Census reported 1.7 million hectares harvested in SRH districts out of 2.5 million "actually irrigated" in all areas. The difference, representing privately irrigated cropland, was 68 percent of the 1.2 million hectares of private land that could be irrigated. This fraction was multiplied by the number of hectares of private land that could be irrigated in 1940, 1950, and 1960. The results were multiplied by the volume of water per hectare harvested in the SRH irrigation districts. Intra-census year volumes were interpolated geometrically. [7] The 1948-65 data are from app. B . An index of land area benefited by SRH projects *(27)* was linked to this series in making the 1940-48 estimates. [8] Sum of estimated private and SRH water volumes used. [9] A weighted sum of the input indices, with weights equalling input shares in the total cost of purchased inputs.

percent a year during 1940-53 and at an even higher rate—9.2 percent annually—during 1954-65. These high growth rates are explained by the increasing profitability of purchased inputs during the first part of the period and, what amounts to the same thing, by an implied, complementary relation between fertilizer use and irrigation water availability during 1954-65.

From 1940 through 1953, most purchased inputs became relatively cheap sources of growth. Prices received by farmers for 37 principal crops increased an average of 12.7 percent a year, while prices of purchased inputs increased only 3.2 percent (see app. B). After 1953, however, relative prices fell for 2 years, increased for 2 years, and then fell again, producing no sustained, highly favorable trend in relative prices as in 1940-53. Crop price increases dropped to an average rate of about 4.0 percent a year and purchased input prices increased 3.8 percent. While the growth rate of some purchased inputs correspondingly declined, availability of irrigation water provided by the Government continued to expand rapidly.

Fertilizers—In recent years, fertilizers have accounted for about one-half the value of purchased inputs in Mexican agriculture. Consumption was negligible during the 1940's and in 1950, only 14,000 metric tons of primary nutrients were used. But by 1955, consumption had risen fourfold; it then doubled in each of the succeeding 5-year periods.

Although fertilizer use in Mexico has increased rapidly in recent years, the country's average of 23 kilos of primary nutrients per cultivated hectare is not high in Latin American terms. The relatively low consumption level reflects the apparent dependence between fertilizer consumption and irrigation in areas of low rainfall (illustrated in part by fig. 7) and the small share of total cropland irrigated.

Guanos y Fertilizantes S.A. (Guanomex), a Government-owned corporation, produces about two-thirds of the commercial fertilizers used in Mexico. The corporation operates with import protection but sets farm prices of fertilizer well below production costs *(18)*. The resulting losses are absorbed by the Government petrochemical monopoly, PEMEX (Petroleos Mexicanos).

Insecticides—Data on insecticide imports for agricultural uses are reported in Mexico by the Direccion General de Estadistica, SIC, in four main classifications: arsenics, organics, inorganics, and "no detail" (table 18). The "no detail" category is chiefly insecticides so new as to not yet have been classified by Mexican customs and not taxed. Unit prices and index numbers for insecticides imported during 1940-65 are given in table 19.

Mexico's first insecticide imports were used by northern cotton producers and were imported from the United States just prior to World War II. Nicotine compounds and calcium arsenic constituted the bulk of these early purchases. DDT figured heavily in imports during the 1950's.

Insecticide mixing plants have been in operation in Mexico since 1947. In 1969, 45 of these enterprises were spread throughout the Republic; 27 were in the principal cotton-producing regions. Of these, half were located in the States of most intensive cotton insecticide use—Tamaulipas and Chiapas—where 15 to 20 applications per crop is not an uncommon practice. Domestic production of active insecticide ingredients, on the other hand, has been a relatively new development. In 1959, two chemical companies—Montrose Mexicana and Diamond Black Leaf de Mexico—began to produce DDT. Diamond Black Leaf later began producing BHC. Fungicides (for example, Maneb, Zineb) are now produced by domestic companies as well by Dow Chemical and Quinsa plants located in Mexico. Herbicides are manufactured by Dow, Alfbeck, Polaquimica, Quinsa, and Industria Nacional. The recent progress of local industry has put Mexico in the position of providing herself with roughly half the value of domestic insecticide consumption. Consumption of finished insecticide products may have been as high as one-half billion pesos in 1963. Liquid insecticide products accounted for about one-quarter of 1963 consumption.

Mexicans attribute the relatively recent growth of their local insecticide industry to the United States. They explain that insecticide producers in the south of the United States frequently overestimated their own domestic demand. In the years in which this occurred, Americans would enter Mexico with their residual supplies and sell them at prices lower than those of domestic producers.

Labor

As a factor of production, labor has a special role in economic development. Not only does it account for a part of the growth in output, but where labor goes, what it does, and what it earns reflects—in a general way—patterns of economic progress.

In early stages of economic development, agriculture is the principal occupation. As development progresses, nonfarm production begins to increase more rapidly than farm production. Forces are set in motion which can lead to an improvement in the domestic terms of trade for farm products.

This can trigger a response from private individuals and/or government characterized by the migration of "pioneering" populations and some investment in the now more attractive agricultural enterprise. If available, new lands are brought into cultivation or other means are sought to expand agricultural production.

Elements of this early "expansive stage" of development began to operate in Mexico at the turn of this century. Expansion was interrupted by the 1910-17

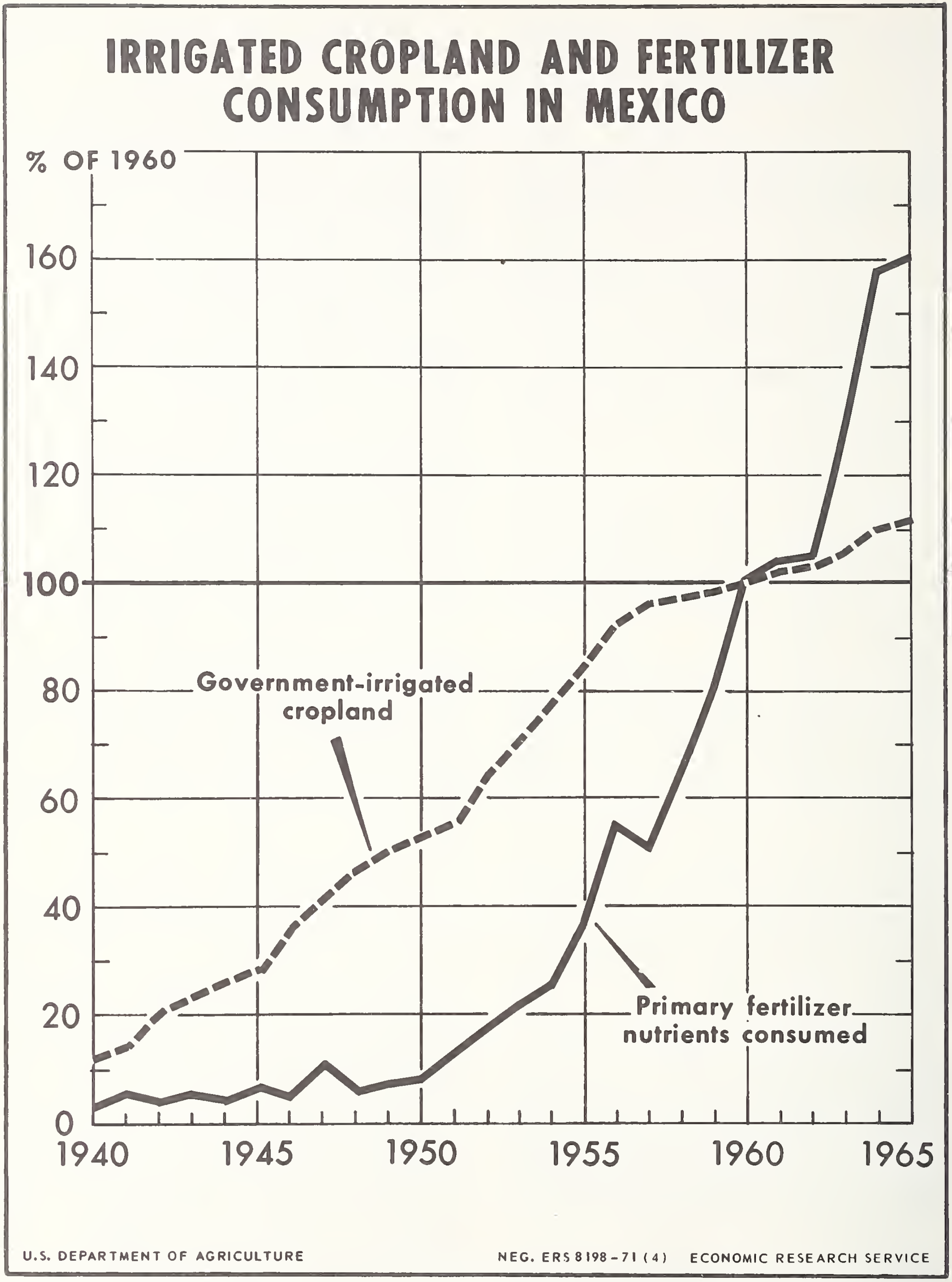
IRRIGATED CROPLAND AND FERTILIZER CONSUMPTION IN MEXICO
% OF 1960
160
140
120
100
80
60
40
20
0
1940
1945
1950
1955
1960
1965
Government-irrigated cropland
Primary fertilizer nutrients consumed
U.S. DEPARTMENT OF AGRICULTURE
NEG. ERS 8198-71 (4)
ECONOMIC RESEARCH SERVICE

Figure 7

Table 18.—Insecticide imports for use in agriculture, by value and quantity, Mexico, 1940-65[1]

Year	Value[2]					Quantity				
	Arsenics	Organics	Inorganics	No detail[3]	Total	Arsenics	Organics	Inorganics	No detail[3]	Total
	1,000 pesos	*1,000 pesos*	*1,000 pesos*	*1,000 pesos*	*1,000 pesos*	*Metric tons*	*Metric tons*	*Metric tons*	*Metric tons*	*Metric tons*
1940	140	18	243	181	582	270	3	44	115	432
1941	222	48	415	223	908	417	8	126	86	637
1942	731	28	393	281	1,433	1,250	4	148	238	1,640
1943	706	73	107	432	1,318	862	11	101	330	1,304
1944	245	22	324	734	1,325	310	4	203	250	767
1945	59	35	524	2,140	2,758	63	4	346	733	1,146
1946	69	70	666	1,586	2,391	76	5	115	526	722
1947	754	13	16	1,746	2,529	406	20	51	810	1,287
1948	350	1,330	14	2,367	4,061	210	767	45	859	1,881
1949	212	4,775	2	2,367	7,356	107	1,854	---	651	2,612
1950	1,268	16,152	51	13,586	31,057	649	5,244	15	4,499	10,407
1951	4,979	24,552	---	41,628	71,159	2,429	3,878	---	11,472	17,779
1952	1,879	16,122	198	26,074	44,273	1,100	2,778	51	7,801	11,739
1953	449	10,823	48	30,913	42,233	421	2,594	38	12,520	15,573
1954	152	24,361	135	44,050	68,698	49	3,892	180	7,393	11,514
1955	277	52,652	20	90,003	142,952	99	10,140	10	20,277	30,526
1956	442	87,152	465	51,505	139,564	82	15,862	55	5,918	21,917
1957	1,035	102,221	442	31,048	134,746	174	14,565	46	2,652	17,437
1958	440	154,503	267	49,771	204,981	45	20,342	19	4,421	24,827
1959	270	79,480	1,054	29,282	110,086	122	9,211	22	2,121	11,476
1960	40	60,303	1,031	33,205	94,579	6	6,427	13	1,962	8,408
1961	120	59,852	920	44,566	105,458	24	6,213	7	2,480	8,724
1962	732	73,004	294	89,904	163,934	79	7,329	10	3,859	11,277
1963	801	48,151	176	59,625	108,753	130	5,014	1	2,466	7,611
1964	116	61,147	290	86,322	147,875	43	6,547	2	4,926	11,518
1965	71	108,832	153	29,736	138,792	61	8,618	2	1,097	9,778

[1] Free and fiscal zone imports. Excluded are insecticides used for household, fumigation, or noncrop purposes, and inert ingredients used in insecticides. [2] For arsenics, organics, and inorganics, value data do not include import taxes. [3] At the time the data were reported, items in this category were so new as to not be classified by Mexican customs and not taxed. The number of insecticide imports in this category was reduced in 1947 and 1956.

Source: Direccion de Estadistica, SIC, Mexico.

Table 19.—Import price of imported insecticides, Mexico, 1940-65

Year	Arsenics	Organics	Inorganics	No detail	Index[1]
	Pesos per metric ton	*Pesos per metric ton*	*Pesos per metric ton*	*Pesos per metric ton*	
1940	519	6,000	5,523	1,574	38.9
1941	532	6,000	3,294	2,593	40.7
1942	585	7,000	2,655	1,181	44.1
1943	819	6,636	1,059	1,309	42.2
1944	790	5,500	1,596	2,936	38.3
1945	937	8,750	1,514	2,919	57.8
1946	908	14,000	5,791	3,015	89.5
1947	1,857	650	314	2,155	7.8
1948	1,667	1,734	314	2,755	15.4
1949	1,981	2,575	[2] 3,400	3,943	22.7
1950	1,954	3,017	3,400	3,020	25.5
1951	2,050	2,791	[3] 3,641	3,629	23.4
1952	1,708	8,769	3,882	3,339	58.7
1953	1,067	20,298	1,253	2,469	126.1
1954	3,102	22,393	759	5,958	145.1
1955	2,798	10,081	2,000	4,439	68.5
1956	5,390	9,740	8,455	8,703	74.4
1957	5,948	5,457	9,609	11,707	54.3
1958	9,778	2,964	14,053	11,258	38.6
1959	2,213	6,498	47,909	13,806	64.8
1960	6,667	11,359	79,308	16,924	100.0
1961	5,000	7,750	131,429	17,970	80.9
1962	9,266	8,343	29,400	23,297	93.0
1963	6,161	21,705	176,000	24,179	176.4
1964	2,698	14,989	145,000	17,523	123.6
1965	1,164	8,753	76,500	27,107	103.0

[1] Calculated by weighting the 1960 import price of each category by the quantity imported in 1960. [2] Assumed to equal the 1950 price. [3] One half the sum of 1950 and 1952 prices.

Source: Table 18.

Revolution, but resumed in the late 1920's and was subsequently reinforced by the Government's transportation and irrigation investments. The impact upon production was first visible in the 1930's.

By the 1940's, Mexico's agricultural production had expanded rapidly relative to the rest of the economy. Expansion not only served to "balance" growth, but reversed the currents of development. The domestic terms of trade (indicated in part by food prices relative to prices of nonfood items, see pp. 14-15) turned against agriculture and in favor of other sectors.

This reversal might have marked a new stage of development characterized by workers leaving agriculture for other industries. But the changes that occurred after 1940 helped maintain the profitability of farming and labor's reward in agriculture. The favorable trend in purchased input prices, the Government's expansion of irrigated acreage, increased use of nonlabor inputs, technological changes, and integration of domestic with foreign markets all helped improve labor's return in agriculture.

In 1930, the average product of the agricultural labor force was 15 percent of that obtained by the industrial labor force *(27,* p. 37). By 1940, it had risen to 17 percent. In 1950 and 1960, it stood at 20 percent. Thus, while labor's product is still low in agriculture, it has improved in relative terms. Average wages paid farm and nonfarm labor were not reported until 1950. A comparison of data for that year and 1960 show a slight decline in the ratio of farm to nonfarm wages during the period (see app. table A-2). These averages, however, blur the fact that farm wages kept pace with those paid in the nonfarm sector in major, rapid-growth states outside the southcentral highlands (Coahuila, Chihuahua, Nuevo Leon, San Luis Potosi, Tamaulipas, Sinaloa, Sonora, and Aguascalientes).

While migration from rural areas has occurred, population there rose after 1940. Rural population increased 1.5 percent annually during 1940-65, with little intraperiod change in trend. The difference between this rate and the 4.5 percent urban population growth rate is accounted for primarily by two streams of migration, one internal and one external.

Internal migration produced inflows of people to states with large industrial centers, such as Nuevo Leon and the Federal District (table 20). Concurrent with this rural-urban shift, Mexicans also moved internally from poorer to richer rural areas. Of all rural areas, the Pacific South Region had the highest net rate of out-migration during 1950-60, while the wealthiest, most rapidly growing agricultural region, the Pacific North, experienced net in-migration—particularly to the border State of Baja California and the State of Sonora. A second stream of migration affecting rural population

Table 20.—Changes in the structure of the population, Mexico, 1950-60[1]

Region and State	Population growth rate	Excess births over deaths	Rate of out-migration: Total	Rate of out-migration: To other States within region	Rate of out-migration: To States outside region	Rate of in-migration: Total	Rate of in-migration: From other States within region	Rate of in-migration: From States outside region
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
North:	32.1	34.8	8.3	3.9	4.4	5.5	3.7	1.8
Coahuila	25.1	35.0	10.4	6.7	3.7	0.6	-0.3	0.9
Chihuahua	44.0	36.3	3.0	0.4	2.6	10.8	7.9	2.9
Durango	19.7	35.0	15.4	7.0	8.4	0.2	-0.3	0.5
N. Leon	45.5	34.4	4.5	1.5	3.0	15.8	12.4	3.4
S. L. Potosi	22.3	22.3	7.7	4.3	3.4	0.9	0.1	0.8
Tamaulipas	43.1	40.0	5.9	2.6	3.3	9.4	5.2	4.2
Zacatecas	22.5	35.4	12.6	5.2	7.3	-0.2	0.0	-0.2
Gulf:	31.8	32.1	4.8	1.2	3.6	4.5	1.2	3.3
Campeche	37.6	43.0	13.4	0.3	13.0	8.0	6.0	2.0
Q. Reo	94.3	68.5	25.7	2.1	23.6	51.5	46.0	5.5
Tabasco	36.4	39.8	5.6	3.1	2.5	2.2	1.0	1.2
Veracruz	33.3	31.6	3.4	0.2	3.2	5.0	0.6	4.4
Yucatan	18.7	24.2	6.2	3.7	2.5	0.7	-0.0	0.7
Pacific North:	50.4	41.9	8.2	4.5	3.7	16.7	4.8	11.9
B. Calif.	126.5	66.0	10.8	4.0	6.8	71.4	18.3	53.1
B. Calif. T.	31.8	38.4	19.0	1.0	18.0	12.4	3.9	8.5
Nayarit	33.8	36.8	8.1	4.9	3.2	5.1	0.4	4.7
Sinaloa	31.7	35.7	9.1	5.9	3.2	5.1	0.9	4.2
Sonora	53.3	42.6	4.5	2.8	1.7	15.2	6.6	8.6
Pacific South:	26.8	31.8	6.3	0.4	6.2	1.3	0.1	1.2
Colima	44.6	44.2	13.6	0.2	13.4	14.0	0.3	13.7
Chiapas	31.8	36.0	5.5	0.0	5.5	1.2	0.1	1.1
Guerrero	28.8	33.1	5.6	---	5.6	1.3	0.2	1.1
Oaxaca	21.1	27.3	6.5	0.1	6.4	0.4	0.0	0.4
Central:	36.7	35.3	6.4	4.4	2.0	7.7	4.3	3.4
Aguas-Calientes	28.7	44.8	18.6	13.6	5.0	2.6	0.9	3.5
D. F.	59.0	44.9	3.6	2.6	1.0	17.7	10.1	7.6
Guanajuato	30.1	35.0	8.3	5.7	2.6	3.5	2.1	1.4
Hidalgo	16.2	23.0	9.5	7.8	1.7	2.6	1.3	1.3
Jalisco	34.4	40.5	6.4	2.2	4.2	5.3	2.3	3.0
Mexico	35.4	24.3	1.5	1.4	0.1	12.5	9.5	3.0
Michoacan	29.6	39.2	10.5	7.7	2.8	1.2	0.4	0.8
Merelos	40.8	32.5	4.5	3.0	1.5	13.0	3.1	9.9
Puebla	21.2	25.5	5.6	4.4	1.2	1.3	0.4	0.9
Queretaro	23.9	33.8	11.4	7.4	4.0	1.6	1.2	0.4
Tlaxcala	21.5	30.7	10.4	9.2	1.2	1.3	0.1	1.2

[1] 10-year rates per hundred of 1950 population.

Source: *(35)*.

resulted from the U.S.—Mexican Bracero Program. From September 1942 through 1965, U.S. farmers contracted annually for as many as 444,000 Mexican farm laborers *(19,* p. 65). While labor contracts were of a temporary nature, the upward trend in this 23-year program during the 1940's and 1950's implied reductions in Mexico's rural population.

The average rate of increase in the farm labor force during 1940-65 was approximately equal to the rate of rural population growth. But unlike the steady expansion of rural population, increases in the farm labor force varied sharply by category, farm type, and time period of reference. After 1940, agricultural employment increased 2.7 percent a year (table 21). While unpaid family member participation declined (primarily because of a decrease in the land reform, ejido sector), numbers of farmers and equivalent full-time paid workers increased fairly rapidly. After 1950, employment increased more slowly. The number of farmers showed very little change and the number operating the smallest size private units actually declined by 10 percent.

Land

Land, which is the most important capital input in Mexican agriculture, represents well over half the value of all physical capital. While most farmland is pasture, the largest investment is represented by cropland (73 percent). Cropland ownership is about evenly divided between the private and the ejido sectors.

The stock of farmland, including pasture and cropland adjusted for quality, increased rapidly during

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Table 21.–Agricultural labor force statistics, by farm and labor category, Mexico, 1940, 1950, and 1960

Year and farm category	Labor category		
	Farmers	Unpaid family workers	Hired laborers
	Thousands	*Thousands*	*Thousands*
1940:			
Large private farms	290	336	[1]134
Small private farms	929	[2]1,244	n.a.
Ejido farms[3]	1,223	1,764	[4]5
1950:			
Large private farms	361	556	[5]239
Small private farms	1,005	[2]1,347	[6]37
Ejido farms[3]	1,553	1,016	[7]42
1960:			
Large private farms	447	548	[8]271
Small private farms	899	1,205	[9]32
Ejido farms[3]	1,598	1,511	[10]54

[1] Number of "jornaleros y peones" (hired workers) and "personas de otras categorias" (other categories) reported in the 1940 Agricultural Census times 0.2467, or 544,000×0.2467. The source of the fraction is explained in note 8 below. [2] It is assumed the ratio of family workers to farmers was the same as reported in the 1960 Agricultural Census. [3] Includes all ejidatarios reported in the Agricultural Censuses for 1940, 1950, and 1960, respectively. [4] Wage bill reported in the 1940 Population Census divided by 300 times the daily wage of U.S. $1.09 estimated by *(13,* pp. 1222-1250). [5] Number of "jornalers" and "otros" reported in the 1950 Agricultural Census times 0.2467, or 969,000 times 0.2467. The source of the fraction is explained in note 8 below. [6] Equals the wage bill of 64,313,000 pesos reported in the 1950 Agricultural Census divided by 12 times the Population Census composite wage for May 1960 of 145 pesos. The resulting figure represents 18 percent of the 210,000 hired laborers reported in the Agricultural Census as working small private farms. [7] Computed as explained for this type of labor for 1940. [8] The wage bill reported in the 1960 Agricultural Census divided by 12 times the Population Census wage for May 1960 (354 pesos) equaled 24.67 percent of "jornalers" reported in the Agricultural Census as working. This fraction was multiplied by 1,099,000, which is the sum of "jornalers" and "empleado y trabajadores" (i.e., each type of farm worker) to estimate the number reported here. [9] Equals the wage bill of 136 million pesos reported in the 1960 Agricultural Census divided by 12 times the Population Census composite wage for May 1960 of 354 pesos. [10] Wage bill of 228 million pesos reported in the 1960 Population Census divided by 12 times the May 1960 wage of 354 pesos.

the 1940's (table 22).[11] After the early 1950's, expansion slowed, resulting in an overall annual increase of 2.0 percent during 1940-65. The most variable element of this expansion was cropland harvested. During 1940-53, it increased at an average annual rate of 2.5 percent. Pastureland increased 1.8 percent annually. After 1953, however, cropland harvested expanded only 0.8 percent annually, while pastureland continued to rise at a rate equal to that of the earlier period.

Not much of the recorded increases in cropland harvested can be attributed to reductions in the proportion of cropland idle or reductions in cropland planted but lost prior to harvest. The Mexican Census of Agriculture in 1940, 1950, and 1960 showed that 42 to 46 percent of the cropland had been temporarily withdrawn from cultivation for rotation or fallow. Similarly, the percentage of cropland planted, but lost to diseases or droughts, frosts, and other weather factors, has been reasonably constant: 14 percent in 1940 and 13 percent in 1950 and 1960.

Thus, the principal sources of increase in cropland harvested stemmed from multiple-cropping, opening of new lands through irrigation, and conversion of pasture.

Multiple-cropping is a relatively new development in Mexico and the land area affected still represents only a small fraction of cropland harvested. The 1950 Mexican Census of Agriculture reported that 41,000 hectares were multiple-cropped.[12] However, by 1960, the area multiple-cropped increased almost 900 percent. While some of this was associated with irrigated regions, largest increases came from areas with seasonal underemployment of labor, few off-farm employment opportunities, and good, year-round weather.[13] The Pacific South Region, including the southern States of Oaxaco, Colima, Chiapas, and Guerrero, is characterized by these conditions and the land area multiple-cropped there increased 2,900 percent between 1950 and 1960.

Cropland area benefited by projects of the Secretariate of Water Resources increased from 147,000 hectares in 1940 to 1.6 million hectares in 1965.[14] Largest gains were made between 1940 and 1954. These dramatic increases were largely the product of private interests, as the SRH projects do not involve direct acquisition of land or its conversion for crop production. The Mexican Government only obtains the dam site and constructs the dam and distribution and drainage facilities. Government agencies exercise some control over the size of the new farm units and, as a practical matter, ensure an equitable division of the newly irrigated land between private and ejido farmers, but that is the extent of direct, public participation.

Land conversion accounted for most of the expansion of privately owned, dryland crop areas after 1940. Conversion has taken two general forms and has been most significant in areas with adequate rainfall. The

[11] "Quality" was defined by the price of land. Farmland was taken equal to the sum of cropland plus pastureland deflated by the ratio of the price of pasture to the price of unirrigated cropland. The actual quantitites of farmland reported by the Census in 1940, 1950, and 1960 were 71.0, 87.3, and 102.9 million hectares, respectively.

[12] According to a special summary publication of the Agricultural Census entitled "Totales Comparativos en 1930, 1940, y 1950," 981,000 hectares were multiple cropped in 1940. However, the 1940 Census did not report multiple-cropped land. Hence, the special summary publication is puzzling and has been disregarded.

[13] An attempt was made to estimate the importance of multiple cropping by comparing cropland harvested data for the irrigation districts with data on the land area serviced each year with irrigation water. As the harvested area seldom exceeded the land area serviced, the only conclusion that could be reached was that multiple cropping was unimportant relative to crop losses.

[14] All land affected by projects of the Secretariate of Water Resources increased from 267,000 hectares in 1940 to 2.5 million hectares in 1965. These data include land "improved," as well as "new lands."

Table 22.—Farmland use and yield data, Mexico, 1940-65

Year	Cropland harvested[1]	Adjusted pasture[2]	Adjusted farmland[3]	Output per unit of— Cropland harvested	Pasture-land	Farm-land
	1,000 hectares	*1,000 hectares*	*1,000 hectares*	*1960 pesos*	*1960 pesos*	*1960 pesos*
1940	6,973	10,111	25,958	619	376	313
1941	7,275	10,293	26,827	588	370	301
1942	7,553	10,475	27,641	655	481	362
1943	8,054	10,667	28,971	690	491	372
1944	7,362	10,859	27,591	724	441	367
1945	7,751	11,051	28,667	751	461	381
1946	7,791	11,253	28,960	740	434	368
1947	7,666	11,456	28,879	792	398	368
1948	8,056	11,658	29,967	820	495	413
1949	8,531	11,870	31,258	853	487	418
1950	9,076	12,128	32,558	886	480	426
1951	9,866	12,322	34,744	868	496	422
1952	9,910	12,516	35,038	880	498	427
1953	9,450	12,723	34,200	892	505	434
1954	10,103	12,916	35,877	901	543	449
1955	10,696	13,135	37,444	971	558	473
1956	10,860	12,249	36,930	1,036	653	521
1957	10,934	13,547	38,397	1,019	623	510
1958	10,681	13,765	38,040	1,093	625	533
1959	11,735	13,983	40,653	1,090	592	518
1960	11,444	14,225	40,234	1,072	557	502
1961	10,625	14,444	38,618	1,202	583	549
1962	11,305	14,675	40,368	1,218	600	559
1963	11,129	14,905	40,198	1,269	608	577
1964	11,057	15,148	40,277	1,427	609	621
1965	11,876	15,390	42,381	1,431	615	625
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Compound rate of change:						
1940-53	2.5	1.8	2.2	3.2	[4]-1.6	2.5
1954-65	0.8	1.8	1.2	3.9	[4] 0.4	2.6
1940-65	2.2	1.7	2.0	3.1	1.9	2.6

[1] 37 principal crops, see app. B for sources and methods of computation. [2] Intradecade years interpolated from decennial reports of the Mexican Agricultural Census. [3] Includes the first 2 columns plus cropland idled and cropland planted, but lost prior to harvest. [4] Not statistically different from zero at $t_{0.025}$.

common practice of land conversion, which is simply to plow permanent, natural pastures, is undertaken by small farmers who use primarily their own labor and, in cases of larger scale conversion, hire machinery and labor. A less prevalent practice has been a two-stage process of conversion. Trees are first cleared, large obstacles are removed from the fields, and heavy thickets are burned. For 3 to 5 years, this new land is left to the growth of natural pasture and animals are introduced for grazing. During this period, tree stumps are removed, land is more thoroughly prepared, and at a final stage, the land is made ready for crop cultivation. This pattern of conversion is at present practiced in the States along the Gulf Coast of the Republic.

One of the more interesting aspects of pastureland expansion and conversion to crop production in Mexico is that it was undertaken almost entirely by private farmers. Not only have ejidatarios acquired less than 400,000 hectares through means other than land reform since 1940, but a part of the land they were granted by the Government has been abandoned *(35)* [15] Abandonment has occurred primarily on lands that were classified as pasture.

Those private farmers who expanded their land input apparently reaped a handsome reward for their efforts. The price per unit of all farmland increased 21.1 percent annually in the 1940's and 7.3 percent annually

[15] In 1940 and 1950, 23.5 million and 32.4 million hectares, respectively, had been distributed to ejidatarios *(10)*. In the same years, the Mexican Agricultural Census reported 24.6 million and 34.1 million hectares of ejido crop, pasture, and woodlands. But by 1960, 38.3 million hectares were reported to have been distributed to ejidatarios. The Census, however, reported only 23.3 million hectares of ejido land in 1960. Most of this abandonment occurred on pastureland.

thereafter.[16] These rapid rates of appreciation reduced the equivalent rental cost of land and thus enhanced the net product obtained from employment of the land. Reinforcing this effect was a rise in the average product of land (table 22). Real output per unit of quality—adjusted farmland in 1940 stood at 302 (1960) pesos; by 1950, it had risen to 421 pesos and by 1965, to 494 pesos. Because small gains were recorded in livestock output per unit of pastureland, the increase in all farmland output was mainly from the crop sector. During 1940-53, crop output per unit of land harvested increased 3.1 percent annually. After 1953 yields rose at still higher annual rates—3.7 percent.

Livestock Capital

Mexico's cattle, pigs, sheep, and goats are concentrated in the Northern and Central Mesa areas, although a large number of beef cattle are in the Sonora, Tamaulipas, and Veracruz States. Cattle represented about 85 percent of the 1960 value of livestock. Pigs, sheep, and goats were thus of minor importance.

Cattle production has traditionally been divided according to the two markets it serves. In the north of the Republic, because of poor pasture, a constant threat of drought, and proximity to the border, cattle are produced for export to U.S. feeder or stocker markets. At the time of shipment, animals weigh about 450 pounds and are 8 to 12 months old. During 1940-65, U.S. imports averaged slightly more than 300,000 live head a year.

Cattle in the Central Mesa and in the States of Sonora, Tamaulipas, and Veracruz have traditionally provided meat and milk to the domestic market, comprised principally of Mexico City, Guadalajara, and Monterrey. Beef cattle, originating in natural pastures, are fattened on seeded, or improved, grasslands in the Huasteca (Tamaulipas State) or Sotavento (Veracruz State) regions and then shipped to urban markets at weights of 600 to 850 pounds. Dairy cattle of the Central Mesa are concentrated in the Mexico City milk shed, which includes the Federal District and Hidalgo, Guanajuato, Puebla, Tlazacala, Queretaro, and Mexico States. More than one-quarter of Mexican milk production is consumed in this single area each year *(7)*.

Cattle for export in the northern areas rely directly on natural pastures. Few resources are committed for ensilage and hay production. Average pasture quality is poor, often consisting of only yucca tops and mesquite beans. Range capacity is low, and the typical livestock enterprise is rather extensive. A result is inadequate herd control, which in addition to dispersed water points and limited fencing and corrals, makes for year-round calving, low calving rates, and high mortality rates. Drought is the biggest killer. Losses of 5 to 30 percent of the herd are reported during the "desperate months" of April and May.

Further south, livestock enterprises are less subject to the vagaries of weather and are generally smaller in scale. Some meat animals, and almost all dairy cattle, are fed alfalfa, other legumes, green forage corn, sorghum, and even concentrated rations (although Mexico's production of mixed feeds is used primarily for poultry).[17] Scrub cattle are typically held on small, 5-hectare mixed enterprises. Dairy cattle production averages only about 350 liters (92 gallons) of milk a year. Some good quality cows (90 percent Holstein-Friesan) are raised near the Federal District, but these probably represent no more than 20 percent of the stock of dairy animals in the milk shed *(31)*. Beef cattle are of very mixed origin. Apart from quality Hereford stock on the Northern Mesa and sturdy, tick-resistant Cebu in tropical areas, "corriente" or "criolla" breeds predominate throughout Mexico.

The livestock capital input has been neglected in the process of Mexican agricultural development. Although it is the second most important form of physical capital, only small improvements have been recorded in the generally poor quality of the livestock herd. In 1924, a large number of registered beef cattle were introduced into the country as a result of a drought in Texas. U.S. cattlemen were granted concessions to graze 40,000 head of Hereford stock on Mexican grasslands; in exchange, Mexico received half the calf crop. In the mid-1950's, the U.S. Export-Import Bank provided Mexico loans for herd improvement. These two programs added 20,000 head of registered beef and dairy animals to Mexico's livestock population.

In 1946, national livestock stations with breeding services were established by the Mexican Government, and by 1957 eight stations were in operation. But during 1958-65, the Mexican Government's annual budget allocations for these stations (US$40,000) remained unchanged. A Government artificial insemination service was formed in 1950 and was subsequently expanded to include 10,000 head a year. By 1957, it had a budget of almost US$100,000. However, these levels did not change in later years.[18]

Also, the number of animals did not increase significantly during 1940-65. The stock of meat and milk producing units increased 25 percent a year, or at a slightly slower rate than the increase in total population (table 23).

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[16] Only the Ejido Bank could provide an offset to this by making loans based on the discounted value of the future returns to the land. However, the vast majority of the Bank's loans are based only on the current year's return.

[17] The Office of the Agricultural Attache, Foreign Agricultural Serv., U.S. Dept. of Agriculture, Mexico, D.F., claims that about 85 percent of mixed feed production is poultry feed.

[18] The budgets of these and other programs benefiting livestock are presented in table 24.

Output per animal unit showed some gains in 1940-53, but average yields remained almost unchanged during 1954-65. For the entire 1940-65 period, output per animal unit increased only a third as fast as crop output per unit of land harvested.

There are several reasons for the comparatively slow growth of Mexico's livestock sector and for its present-day organization being behind that of the crop sector.

The Government's agricultural policies have centered on the crop sector rather than the livestock sector. Public expenditures on livestock programs have been limited (table 24). Biggest public investments have been for improving cropland through irrigation, with less attention given pastureland improvement. Prices of corn, sorghum, and wheat have been supported, while milk prices have been controlled in large urban areas. The majority of official bank credits have gone to crop, rather than livestock, production.[19] More research has been devoted to crops than to livestock, and there has been limited public support to control animal diseases such as blackleg, anthrax, piroplasmosis, brucellosis, tuberculosis, ticks, bat rabies, and spittle bugs—all of which take particularly heavy tolls of animals and pasture outside the arid regions of the Northern and Central Mesa.

Land reform has also contributed to the slow growth of the livestock sector. The Agrarian Code states that private owners of pasture are exempt from expropriation if they own no more land than is necessary to graze 500 bovine animals. In practice, this limitation on size was

[19] These data are contained in the Informe de Laborers of each of the official agricultural banks.

Table 23.—Indexes of livestock capital and related data, Mexico, 1940-65

(1960=100)

Year	Livestock capital[1]				Total[2]	Output per animal unit[3]	Pasture per animal unit[4]
	Cattle	Pigs	Sheep	Goats			
1940	61	85	86	70	64	75	111
1941	61	88	88	70	64	75	113
1942	61	90	91	71	64	98	115
1943	60	91	94	72	64	103	117
1944	62	93	97	73	66	91	115
1945	64	99	101	74	68	94	115
1946	65	105	103	75	69	90	114
1947	65	107	107	75	70	81	116
1948	64	110	110	75	69	106	119
1949	66	113	111	76	71	103	117
1950	70	116	109	78	75	97	113
1951	73	117	108	80	77	100	113
1952	76	121	109	83	80	99	110
1953	77	127	108	85	82	99	109
1954	81	131	109	88	86	102	106
1955	85	134	109	91	89	103	103
1956	89	134	110	93	93	109	100
1957	94	133	110	95	97	109	98
1958	97	123	109	97	99	109	98
1959	97	111	105	99	98	106	100
1960	100	100	100	100	100	100	100
1961	102	83	93	101	100	106	102
1962	103	62	83	101	99	112	103
1963	108	63	75	102	103	111	102
1964	113	64	65	102	107	108	100
1965	119	65	53	103	112	106	96
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Compound rate of change:							
1940-53	1.9	3.1	1.9	1.4	1.9	1.6	-0.1
1954-65	3.1	-0.9	-2.2	1.3	1.9	0.3	-0.1
1940-65	2.9	-0.8	0.0	1.8	2.4	1.1	-0.7

[1] Annual estimates made by interpolating 1940 and 1960 Agricultural Census inventory reports with marketings. This procedure implied constant net rates of reproduction per 100 units of cattle, pigs, sheep, and goats of 19.8, 26.3, 10.5, and 8.7, respectively. [2] A weighted average of the indices shown for each animal class. The weights, corresponding to 1960 shares of the value of all inventories, were 0.85, 0.07, 0.03, and 0.05, respectively, for cattle, pigs, sheep, and goats. [3] An index of livestock output divided by the index of total livestock capital. [4] An index of pastureland divided by the index of total livestock capital.

Source: *(41)*.

Table 24.—Government expenditures for livestock programs, Mexico, 1940-65

Year	Laboratory analysis of products	Pig recovery program	Ejido sheep program	General livestock development	Aftosa prevention	Livestock research	National center for livestock research
	Pesos	*Pesos*	*Pesos*	*Pesos*	*Pesos*	*Pesos*	*Pesos*
1940	---	---	---	---	---	188,882	---
1941	---	---	---	---	---	155,882	---
1942	---	---	---	---	---	169,889	---
1943	---	---	---	---	---	162,654	---
1944	---	---	---	---	---	150,074	---
1945	---	---	---	---	---	326,214	---
1946	---	---	---	---	---	361,882	---
1947	---	---	---	---	---	361,882	---
1948	---	---	---	---	---	361,882	---
1949	---	---	---	---	---	386,754	---
1950	---	---	---	---	---	386,754	---
1951	---	---	---	---	---	239,922	---
1952	---	---	---	---	---	263,562	---
1953	---	---	---	---	---	289,518	---
1954	---	---	---	---	---	208,338	---
1955	---	---	---	---	---	217,560	---
1956	---	---	---	---	---	232,080	---
1957	50,000	---	---	---	---	232,080	---
1958	50,000	1,500,000	200,000	---	---	232,080	---
1959	50,000	1,500,000	200,000	1,500,000	---	286,800	---
1960	50,000	1,521,354	200,000	1,500,000	168,000	315,480	---
1961	50,000	1,522,000	200,000	1,500,000	168,000	315,480	---
1962	50,000	1,522,000	200,000	1,500,000	168,000	315,480	---
1963	50,000	1,522,000	200,000	1,500,000	168,000	867,168	1,375,711
1964	50,000	1,349,623	200,000	1,500,000	168,000	662,232	2,752,233
1965	50,000	1,217,525	200,000	1,500,000	168,000	867,168	2,781,045

Year	National breeding stations	Promotion of livestock associations	Artificial insemination	Bat rabies campaign	Propogation of seeded pastures	Tick campaign	Poultry recovery program	Production of livestock vaccines
	Pesos	*Pesos*	*Pesos*	*Pesos*	*Pesos*	*Pesos*	*Pesos*	*Pesos*
1940	---	---	---	---	---	---	---	---
1941	---	---	---	---	---	---	---	---
1942	---	---	---	---	---	---	---	---
1943	---	---	---	---	---	---	---	---
1944	---	---	---	---	---	---	---	---
1945	---	---	---	---	---	---	---	---
1946	500	74,326	---	---	---	---	---	---
1947	500	74,326	---	---	---	---	---	---
1948	500	74,326	---	---	---	---	---	---
1949	500	74,326	---	---	---	---	---	---
1950	500	74,326	100,000	---	---	---	---	---
1951	500	---	100,000	---	---	---	---	---
1952	500	---	100,000	---	---	---	---	---
1953	500	---	100,000	---	---	---	---	---
1954	144,645	---	161,070	517,119	200,000	500,000	700,000	---
1955	112,800	---	155,998	623,484	200,000	1,000,000	1,700,000	---
1956	506,513	---	835,782	248,084	200,000	963,000	413,000	---
1957	506,513	---	835,782	609,484	200,000	963,000	1,673,000	450,000
1958	506,513	---	1,135,797	621,484	200,000	963,000	8,673,000	500,000
1959	506,513	---	1,135,797	621,484	200,000	963,000	8,673,000	500,000
1960	547,022	---	1,087,000	549,962	202,100	1,008,286	9,110,743	528,522
1961	548,000	---	1,087,000	550,000	203,000	1,009,000	9,111,000	529,000
1962	548,000	---	1,087,000	550,000	203,000	1,009,000	9,111,000	529,000
1963	548,000	---	1,087,000	550,000	203,000	1,009,000	9,111,000	529,000
1964	548,000	---	1,087,000	473,968	203,000	995,965	8,904,687	280,000
1965	548,000	---	1,089,448	473,968	204,800	995,965	8,544,842	198,154

differentially interpreted, thus creating uncertainty of tenure of livestock enterprises. However, a National Commission to Study Pasture Coefficients (La Comision Nacional para la Determinacion de los coeficientes agostaderos) was established by President Diaz Ordaz in 1966 to develop a less arbitrary restriction.

A related problem is the "livestock inaffectabilities." Under Article 114 of the Agrarian Code, pastures can be decreed "inaffectable" by land reform for a period of 25 years, renewal being available thereafter by application to the Department of Agrarian Affairs. Almost 800 such decrees have been granted to cover 7 million hectares of grazing land (table 25). As a majority were granted prior to the 1950's immunity will terminate during the next 5 years and renewal will be sought by the livestock owners. The Mexican Government, however, has not yet indicated decisively its view with respect to renewal of the "inaffectabilities."

A final problem stems from invasion of pastureland by "squatters" (paracaidistas). Officials of the National Livestock Confederation (CNG) make frequent reference to this issue in public pronouncements and the CNG maintains a legal department for the specific purpose of investigating the "agrarian problem."

Power and Implements

In Europe and the United States, 1.0 horsepower of mechanical power is available per hectare of farmland. The corresponding figure for Latin America is about 0.3, and for Asia, it is less than 0.2 *(50)*. Mexico reportedly ranks high among the developing countries in terms of horsepower available for agriculture, yet the contrast with U.S. agriculture is striking. The 1960 Mexican Agricultural Census reported that 54,537 tractors were distributed among 2.9 million Mexican farm units and 23 million hectares of cropland.

In contrast, in the 1960 U.S. Census of Agriculture, 85 times that number of tractors were reported on just 1.3 times as many U.S. farms and less than seven times as much cropland. Similar contrasts prevail for trucks, threshers, harvesters, seeders, shellers, and electrical motors. Less than a third of Mexican cropland is worked by any form of mechanical power *(34)*.

Table 25.—Pastureland covered by 25-year livestock "inafectabilidades," Mexico, 1937-65

Year	Regions[1]					Total
	North	Gulf	Pacific North	Pacific South	Central	
	1,000 hectares	*1,000 hectares*	*1,000 hectares*	*1,000 hectares*	*1,000 hectares*	*1,000 hectares*
1937					3	3
1938			122		47	169
1939	11		122		85	218
1940	304		177	10	114	605
1941	603		218	14	130	965
1942	1,246	7	222	14	225	1,714
1943	1,447	8	231	34	240	1,960
1944	1,877	20	247	35	256	2,435
1945	2,189	23	282	41	268	2,803
1946	2,526	26	330	48	337	3,267
1947	2,974	37	343	64	428	3,846
1948	3,600	47	358	69	462	4,536
1949	4,195	47	358	70	474	5,144
1950	4,541	50	377	79	482	5,529
1951	5,007	64	393	85	488	6,037
1952	5,431	105	393	85	504	6,518
1953	5,589	108	407	85	543	6,732
1954	5,589	108	407	85	543	6,732
1955	5,589	108	407	85	543	6,732
1956	5,648	108	407	85	543	6,791
1957	5,687	109	407	85	545	6,833
1958	5,778	123	407	85	545	6,938
1959	5,814	158	407	85	545	7,009
1960	5,814	158	407	85	545	7,009
1961	5,814	158	407	85	545	7,009
1962	5,814	158	407	85	542	7,006
1963	5,814	158	284	85	497	6,838
1964	5,803	158	284	85	460	6,790
1965	5,510	158	230	74	431	6,403

[1] These correspond to the regions in the frontispiece.

Source: *(11)*.

However, it would be a mistake to characterize power use in Mexican agriculture by these data alone. One reason is that work animals constitute an important alternative to mechanical power. In 1960, they supplemented the labor of four out of every five Mexican farmers working three-quarters of all cropland. Even though mechanization is growing, Mexican agriculture has reached the stage where animals and plows are used largely in place of men and hoes. The averages also conceal the fact that where machinery is employed, Mexican farms are as fully mechanized as the best U.S. enterprises. However, such farms are few and far between. Most of them are located in the northern half of the Republic. In the States of Baja California, Sonora, Sinaloa, and Nyarit, 65 percent of all cropland is worked with mechanical power during the typical crop year. In the southern States of Colima, Chiapas, Guerrero, and Oaxaca, however, the proportion is only 15 percent *(34)*.

There are some obvious reasons for these regional concentrations. In the southern regions, where the topography is rough, the rocky, tilted parcels of cropland are not easily accessible to farm machinery. Also, the average farm size is small in the south. While this need not have resulted in uneconomic use of larger power units, possibilities for their division into effective smaller units through rental or other sharing arrangements are limited by the extent of transportation networks and interfarm roads. In the north, farms are larger and interfarm access roads are more numerous. In the south, machinery repair and maintenance facilities are inadequate. The reverse is true for northern farmers, especially those in the Mexicali area of Baja California, which is just a few miles from the industrialized Imperial Valley of Southern California. Finally, in the northern "frontier" areas of Mexico, tractors and related implements have for years been used in land clearing, reclamation, transportation, and irrigation projects. As projects were terminated, heavy equipment often became available to farmers.

In addition to regional factors of mechanization, irrigation developments in Mexico are associated with

Table 26.—Indexes of the effective stock of power and implements, Mexico, 1940-65
(1960=100)

Year	Machinery				Plows	Work animals	Total effective stock
	Tractors	Threshers	Other	Subtotal			
1940	10.4	30.3	2.3	12.8	56.5	84.0	35.5
1941	11.2	31.0	4.6	13.6	56.5	86.6	36.7
1942	12.9	30.9	6.9	14.9	56.5	89.3	38.3
1943	14.3	32.1	9.1	16.2	56.5	92.1	39.9
1944	16.3	33.8	11.5	18.1	56.5	94.9	41.9
1945	19.2	33.3	13.7	20.4	56.5	97.9	44.2
1946	22.3	34.0	16.1	23.1	56.5	100.9	46.8
1947	27.4	33.8	19.3	27.4	57.9	104.0	50.5
1948	34.9	34.8	23.6	34.0	67.0	107.2	56.4
1949	40.3	34.1	28.7	38.9	76.3	110.6	61.3
1950	46.9	32.3	34.6	44.7	88.3	114.3	67.0
1951	57.7	35.2	40.7	54.2	90.3	112.8	72.9
1952	61.6	44.1	46.9	58.6	92.8	111.3	75.6
1953	65.3	49.3	53.3	62.6	93.9	109.9	77.9
1954	70.5	62.2	59.7	68.7	95.6	108.5	81.6
1955	78.2	70.9	66.3	76.3	97.3	107.1	86.3
1956	83.3	84.5	73.2	82.6	98.2	105.7	90.1
1957	86.8	94.6	80.2	87.3	98.8	104.2	92.8
1958	91.1	97.7	87.0	91.7	99.5	102.9	95.3
1959	95.2	101.4	93.5	95.9	99.8	101.6	97.7
1960	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1961	102.3	104.8	106.3	103.0	100.1	98.9	101.7
1962	104.4	107.4	112.3	105.5	100.1	97.7	103.0
1963	107.3	109.2	118.0	108.6	100.1	96.4	104.6
1964	113.2	114.1	123.3	114.3	100.2	95.2	108.0
1965	114.2	109.9	128.3	114.8	100.2	93.9	108.0
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Compound rate of change:							
1940-53	15.6	2.5	21.6	13.4	4.7	2.4	6.7
1954-65	4.1	4.6	6.9	4.4	0.3	-1.3	2.4
1940-65	10.3	6.6	14.1	9.7	3.0	1.9	4.9

Source: *(32, 34)*.

mechanization. About 80 percent of all irrigated land is worked with some form of mechanical power *(37)*. Three quarters of all farm tractors and about 90 percent of the combines are in the irrigation districts, which include about 15 percent of Mexico's farmers and cropland.

The productivity of mechanical power and equipment is higher on the irrigated land than on the unirrigated land because the flat terrain in the irrigation districts is ideally suited to power equipment. Even though the average size farm there is small (7 hectares) *(37)*, transportation networks and farm roads are well developed, permitting ready access to equipment via rental or custom services. Rural settlements around the irrigation districts have well-developed agricultural industries which facilitate repair and maintenance. Finally, management practices and the utilization of improved seeds, fertilizers, and insecticides are at higher levels in the irrigation districts than outside them. Demand for mechanical power for seed bed preparation, precision seeding and fertilization, power application of insecticides, water control and furrowing, and cultivation and timely harvest operations substantially surpasses the demand in the unirrigated regions of Mexican agriculture.

Data in table 26 reflect in part this link between irrigation and machinery use. With the exception of threshers, all categories of machinery—including tractors, seeders, harvesters, and shellers—increased sharply during 1940-53, when the most rapid expansion occurred in irrigated cropland. The effective stock of tractors doubled almost every 5 years and the composite stock of seeders, harvesters, and shellers ("other machinery") increased fivefold. Similarly, the number of steel plows began to increase during 1940-53, with larger gains recorded in 1946-53 than at any other time during 1940-65. The 13.4-percent annual change in the stock of all machinery during 1940-53 made it the most rapidly growing input in Mexican agriculture.

The overall 1940-65 production contribution of the power-implement input was less spectacular than might be expected on the basis of high growth rates in 1940-53. The rate of addition of new machinery has tapered off in recent years; also, investment in work animals has been large. Thus, with numbers of work animals increasing only 2.4 percent annually during 1940-53 and actually declining since 1950, the total effective stock of power and implements (including work animals) grew 6.7 percent annually during 1940-53 and only 2.4 percent annually during 1954-65.

V.—PUBLIC POLICIES AND PRODUCTIVITY

IRRIGATION

In broad terms, a line could be drawn through the center of Mexico from coast to coast, below which would lie most of the Central Mesa, the Southern Highlands, and the tropical areas bordering the Gulf and Pacific Oceans. Crop yield increases in the Gulf, Pacific South, and part of the Central regions have been modest since 1940 (table 27). The mechanization of agriculture is just getting started. A dominant share of labor is engaged in agriculture, and wages paid farm workers are low. Fertilizers and insecticides were a novelty until quite recently. Improved varieties of corn are in limited supply and are often rejected for their inferior taste.

Table 27.—Regional rates of change in crop production, yield, and area harvested, Mexico, 1940-62[1]

Region[2]	Compound rates of change in—		
	Crop production	Crop yields	Area harvested
	Percent	*Percent*	*Percent*
North	4.8	3.2	1.6
Gulf	5.2	1.7	3.5
Pacific North	9.2	3.1	6.1
Pacific South	5.2	1.2	4.0
Central	3.5	2.9	0.6
Mexico	5.4	3.1	2.3

[1] Based on data discussed in app. B for 37 principal crops.
[2] These correspond to the regions shown in the frontispiece.

North of the imaginery line, certain qualities of agriculture are similar to those in the United States. Crop production growth rates in Mexico's Pacific North Region have exceeded the country's average by a wide margin and yield increases there, as well as in the North Region, have been large. At present, 124 bushels of corn, 110 bushels of wheat, and about 2½ bales of cotton per hectare harvested are commonplace. Investment in power and implements is large, much of the cropland is fertilized, and at least one crop (wheat) is planted almost entirely to improved varieties.

The most important factor making for production differences between the two areas has been the irrigation water provided to the northern regions under Secretariate of Water Resources (SRH) projects. By one account, 83 percent of Mexico's land surface is arid or semi-arid, and irrigation is an indispensable factor of production for 63 percent of cropland cultivated *(29*, p. 8). A much larger proportion of the northern regions falls within this classification. Without irrigation, Mexico's northern frontier could not have been transformed into productive real estate.

In recent years, a third of the northern cropland has been irrigated by SRH, and over three quarters of all SRH-irrigated cropland is in the 12 northern States. Because rainfall is more adequate in the southern half of the country, only a small number of the major SRH projects are located there (fig. 8). In 1960, only 5 percent of all southern cropland was harvested inside SRH irrigation districts.

Figure 8.—Major irrigated areas in Mexico. A = Rio Colorado. B = Ciudad Juarez. C = Rio Altar. D = San Buenaventura. E = Rio Sonora. F = Palestina. G = El Nogal. H = Delicias. I = Rio Yaqui. J = Rio Mayo. K = Don Martin. L = Bajo Rio San Juan. M = Rio Fuerte. N = Rio Sinaloa. O = Region Lagunera. P = Las Lajas. Q = Bajo Rio Bravo. R = Rio Culiacan. S = Rio San Lorenzo. T = Rio de la Sauceda. U = Rio Purificacion. V = Trujillo. W = Rio Frio. X = Xicotencatl. Y = Rio Mante, Z = Rio San Pedro.

AA = Rio Santiago. BB = Rio Tlaltenango. CC = Valle de Banderas. DD = Bajo Rio Lerma. EE = Alto Lerma. FF = Rio Tula. GG = Martinez de la Torre. HH = Autlan. II = Morelia y Querendaro. JJ = La Antigua. KK = Colima. LL = Tieria Calliente. MM = Cutzamala. NN = Valsequillo. OO = Tehuantepec.

During 1946-62, growth rates of land area harvested and crop yields were impressive for crops grown in SRH districts (table 28). Production in these irrigated areas has expanded almost four times more rapidly than outside them.

In 1960, the 1.7 million hectares of cropland harvested in the SRH districts represented just 12 percent of all cropland harvested, and included about 13 percent of Mexico's farm units. Yet the value of crop production in these districts constituted almost a third (31 percent) of the value of all crop production *(34, 36)*.

In the SRH districts, yields are higher on a crop-by-crop basis, and the crops grown have higher gross returns per hectare. In 1960, the value of crop output per hectare inside SRH districts was US$210, compared with US$92 outside SRH districts *(34)*.

Technology and Input Prices

Irrigation developments led to more intensive use of purchased inputs in SRH districts, a result which can be seen in the group means of table 16 and in two studies published by SRH. One indicates that while about one-fifth of all Mexican cropland is reported to receive applications of chemical fertilizers, inside the irrigation districts the proportion jumps to two-thirds *(37)*. Another reports that 79 percent of cropland in SRH districts is worked sometime during the crop year by mechanically powered machinery; yet almost an equal proportion (71 percent) of all Mexican cropland is never even touched by mechanical power *(38)*.

This more intensive use of purchased inputs has been induced by two factors: provision of an irrigation technology—characterized by higher required ratios of use of purchased inputs—plus lower relative prices of purchased inputs inside the SRH districts. The larger production function weights assigned to purchased inputs used inside irrigated regions support this interpretation.[20] One result of the production

[20] See app. A for a further discussion of this point.

Table 28.—Indexes of area harvested and yields for 37 crops, irrigated and unirrigated, Mexico, 1946-62 (1960=100)

Year	Inside irrigation districts[1]		Outside irrigation districts[2]	
	Area harvested	Yields	Area harvested	Yields
1946	35	61	73	77
1947	33	68	72	82
1948	41	67	75	85
1949	41	75	79	87
1950	46	77	86	89
1951	56	68	88	92
1952	58	75	91	89
1953	59	74	86	90
1954	85	85	89	83
1955	94	89	83	100
1956	103	89	94	97
1957	106	93	94	92
1958	93	97	93	103
1959	96	91	93	117
1960	100	100	100	100
1961	121	109	86	108
1962	110	122	97	106
	Percent	*Percent*	*Percent*	*Percent*
Compound rate of change, 1946-62	8.4	3.6	1.3	1.8

[1] From data provided by the Secretaria de Recursos Hidraulicos, Direccion de Estadistica y Estudios Economicos. [2] Each series is based on the difference between the series for all 37 crops and the corresponding one for the SRH irrigation districts.

function weights was to increase the estimated change in total input and correspondingly reduce estimated gains in total factor productivity. This leads to the conclusion that irrigation developments, associated with more intensive use of purchased inputs, explain increases in Mexican agricultural productivity.

Available direct evidence of an "irrigation technology" is presented and discussed in appendix A. Other direct evidence of lower relative prices for purchased inputs inside irrigated regions is derived from the observation that costs of supplying purchased inputs have been lower inside than outside SRH districts. Farms are concentrated in well-defined areas that are accessible to all forms of transportation. The density of the farm market is high. The local SRH agent has at hand names of farm operators and location maps. Additional data can be obtained from local experiment stations, most of which adjoin an irrigation district. Farmland is flat, well-tilled, and free of rocks and debris. This, in addition to the more homogeneous soils, weather, and climatic conditions, reduces the number of input adaptations required to effect sales on a large scale.

Outside the SRH districts, on the other hand, costs of entry into a market are high and the potential volume of sales is limited. Basic agronomic and economic data are lacking. Farms tilting on mountain slopes are not easily accessible. Systems of communication and transportation are inefficient. Altitudes, soils, and climatic conditions vary greatly over short distances, and farm enterprises are geographically dispersed.

Technology and Input Quality

Productivity gains from irrigation developments can also be attributed to another source. In addition to price-technology interactions, irrigation developments resulted in improvement of the quality of a measured unit of purchased inputs.

Public research, extension, and credit facilities are concentrated in the SRH districts. Together with improved communication and transportation facilities, these public facilities have served to augment the effectiveness of purchased quantities of fertilizers, insecticides, seeds, and irrigation water at no additional cost to farmers. Producers can easily learn just how much and what kind of fertilizer to apply, the correct amounts of primary insecticide ingredients, the best seed for each planting date, the correct seeding rate, and the timing and number of irrigations for crops. Literally, then, resource wastage is curtailed and the level of output obtained from any measured amount of input is increased.

Mexico has not committed public resources specifically to the upgrading of ejidatarios and private farmers outside the SRH districts. As a consequence, agencies administering national programs have concentrated their efforts on the SRH districts, since they are every bit as aware as private input suppliers that unit costs of servicing farmers in those areas are lower. These agencies have not concerned themselves greatly with the efficiency of use of traditional inputs. Rightly, it seems they regard the farmer to be the expert on those long-used factors of production and focus their activities on the employment of modern, purchased inputs.

To summarize, two effects of public irrigation developments on productivity have been identified. One derives from changes in relative input prices and technologies. The other derives from the quality-enhancing impacts of SRH developments on measured inputs.

LAND REFORM

The Mexican Revolution was officially born of the "Plan of San Luis Potosi" on October 5, 1910. At the time of the Plan, Mexico was predominately an agrarian country. A third of gross national product originated in the farm sector and about two-thirds of the labor force was engaged in agricultural activities *(12)*.

Of the 4 million agricultural workers in 1910, very few owned land—a mere 3 percent of all rural family heads according to McBride *(25*, p. 154). The rest were farm laborers working on haciendas or latifundios, which were large-scale farm organizations arising from the privileged "encomienda" and "mayorazgo" institutions of the Spanish Colonial Period. Whetten states that by

1910 these large farms "...had gained one of the greatest monopolies over the rural resources and even over the lives of the rural inhabitants that have ever been recorded in the history of any country" *(47,* p. 98).

This is the reason why the 1910-17 Revolution became fundamentally an agrarian movement, attacking the unequal distribution of private property and adopting the maxim "Tierra y Libertad" (Land and Liberty). It also helps explain why, as military success was attained, the first steps taken by the new government were to claim agricultural lands for the Mexican compesino. On January 6, 1915, the Carranza Government decreed that any village had the right to sufficient land for its needs and that such land could be expropriated from adjacent properties. In late 1916, the principle was embodied in Article 27 of the new constitution, which reads in part that "all lands and waters in the national territorial limits belong to the Nation which has the right to transfer their domain." This statement provided the foundation for the first and most complete reform of land ownership in Latin America.

However, little use was made of Article 27 until the administration of Elias Calles (1925-28). Between 1925 and the mid-1940's, Calles and his successors implemented 16 amendments to Article 27. Also, an executive department (the Department of Agrarian Affairs) was established to administer all land reform matters. The 16 amendments, referred to as the Agrarian Code, contain the basic machinery for implementing Article 27. A brief summary of the land reform provisions follows:

1. Three types of grants of agricultural land can be made.
   a. Restitution, which is designed to restore to a community lands that formerly belonged to it. Proof of the existence of the former land right must be presented. This grant has for obvious reasons accounted only for a nominal fraction of all land grants made under the Agrarian Code.
   b. Dotacion, which is an outright grant requiring no evidence of former ownership. Roughly 80 percent of all land grants made in Mexico to date have fallen in this category.
   c. Amplification, which is applied where a previously received "dotacion" is deemed insufficient for a community's needs.
2. Under the dotacion, expropriation is contingent on three conditions.
   a. Submission of a request for land by 20 or more native-born Mexicans to a delegated land reform agency.
   b. Existence of "affectable" private property within a radius of 4 miles of the village in which the solicitors reside. "Affectable" property is defined as holdings exceeding 200 hectares of unirrigated cropland, 100 hectares of irrigated land; 150 hectares of cotton; 300 hectares of bananas, sugarcane, coffee, cocoa fruit trees, or henequen; or more pastureland than is required for the maintenance of 500 head of cattle.
   c. Acceptance of the land request by the local delegation of the Agrarian Affairs Department, the state governor, the central Agrarian Affairs Department, and the President of the Republic.

The owner of land to be expropriated can select tracts of his property that he wishes to retain, but in total, that land must not exceed the affectable limits. The land recipient (ejidatario) has only the right to work the land and pass it to one of his legal heirs. He may not inalienate, encumber, or divide his land. If he leaves the land unworked for 2 successive years, it can revert to the village or the Mexican Government. Until 1943, each ejidatario was to have received at least 4 hectares of irrigated land or 8 hectares of unirrigated land. In 1943, these figures were raised to 6 and 12, respectively, and in 1947, to 10 and 20.

During 1925-40, the Mexican Government also legislated a series of supporting agricultural programs. These were motivated by a growing concern that "the problem of agricultural lands should not be handled (alone) by their redistribution but by the preparation of the man who has to cultivate them..." *(40,* p. 145). The origins of the National School of Agriculture, the rural vocational school, the Ejido and Agricultural Banks, the Secretariate of Water Resources, the agricultural extension service, and the agricultural research establishment are all linked to this period of institutional development in agriculture.

Early Calles-Cardenas Reforms

Well before the agricultural development programs matured, President Elias Calles began land reform on a massive scale, distributing almost 5.7 million hectares of farmland to 500,000 ejidatarios.[21] Mexico's eighth president, Lazaro Cardenas, was the next to follow suit. During 1934-39, his administration expropriated over 16.2 million hectares for 1 million ejidatarios, thus halving the area of private pasture. By 1940, over half of Mexico's land reform had been completed: more than 50 percent of all land had been redistributed, the number of ejidatarios represented well over half the number existing in 1965, and most of the best quality affectable properties had been expropriated (tables 29 and 30).

During the Calles-Cardenas period of intensified reforms, Mexican farm output began an upward trend that continued through the post-1940 period. Until about 1930, production had shown little improvement and crop output had been trending downward, partly because of the civil and political disorders caused by the

[21] Unless otherwise noted, data relating to land distribution are from *(10)*.

Table 29.—Farmland distributed and persons benefited through land reform, Mexico, 1917-64

Period and President	Land area	Persons benefited
	Million hectares	*Thousands*
1917-34 (Elias Calles, 1925-28)	7.7	803
1934-39 (Lazaro Cardenas)	17.4	769
1940-45 (Avila Camacho)	5.3	143
1946-51 (Miguel Aleman)	4.1	82
1952-57 (Ruiz Cortines)	3.2	202
1958-63 (Lopez Mateos)	8.2	253
Total	45.9	2,252

Source: *(10)*. Includes only restitutions, "dotaciones," amplifications.

Table 30.—Cumulative percentages of farmland distributed through land reform, by land category, Mexico, 1917-64

Terminal year	Land type			
	Irrigated	Dry land	Pasture	Other[1]
	Percent	*Percent*	*Percent*	*Percent*
1934	21	19	13	20
1940	79	59	54	50
1946	86	67	66	62
1952	91	76	77	68
1958	95	83	83	76
1964	100	100	100	100

[1] Land not susceptible to use as either cropland or pasture.
Source: *(10)*.

Revolution and its aftermath.[22] Also, during 1910-21, population fell by 900,000, or almost 6 percent. The decrease occurred entirely in the rural population, where migration and Spanish Influenza took heavy tolls.[23]

A significant aspect of the 1930 expansion was the comparatively small increase in total inputs. Table 31 compares data from Mexico's first Agricultural Census (1930) with corresponding data from the more complete 1940 census. With the exception of a miscellaneous expenses category, no input increased at the 4.0-percent annual rate attained by gross farm output. The inference is that total factor productivity gained as a result of the intensified land ownership reforms undertaken by Calles and Cardenas.

[22] See fig. 5, table 8, and (*6, 10,* and *30*).

[23] While the decrease in population is not disputed, its amount has been questioned (*45*, pp. 3-5).

Table 31.—Comparison of agricultural production and input data, Mexico, based on Agricultural Censuses, 1930 and 1940[1]

Item	Unit	1930	1940	Compound rate of change, 1930-40
Production data:				
Cropland harvested[2]	Million hectares	5.83	6.92	1.8
Crop yields	1960 pesos per hectare harvested	480	620	2.7
Crop production[2]	Billion 1960 pesos[3]	2.80	4.29	4.5
Meat production[4]	do.[5]	1.30	1.77	3.2
Gross farm output	do.	4.10	6.06	4.0
Input data:				
Cropland[6]	Million hectares	14.52	14.87	0.2
Irrigated cropland	do.	1.68	1.73	0.3
Pastureland	do.	66.49	56.17	-1.7
Farm operators[7]	Million	0.48	0.68	3.4
Nonoperators[8]	do.	2.47	3.17	2.5
Work animals[9]	do.	4.42	5.29	1.8
Farm machinery[10]	Million 1940 pesos	81.10	75.82	-0.6
Miscellaneous expenses[11]	do.	56.26	96.48	5.5

[1] Except for crop and meat production and farm operators, data for 1930 exclude farms of less than 1 hectare. [2] 37 principal crops. [3] 1960 farm prices received used as weights. [4] Includes only exports of cattle on hoof and for "city slaughter" as reported by Direccion de Estadistics, SIC. [5] 1960 carcass weight prices used as weights. [6] The sum of cropland harvested once, cropland harvested more than once, cropland planted but not harvested, and fallow cropland. [7] Operators with less than 5 hectares of cropland and ejidatarios were weighted by 0.18, which represents the ratio of days worked by hired laborers, on the average, to 260 days. [8] Not reported by the 1930 Census. Estimated by subtracting from the 1940 Census the difference between the 1930-40 increase in farm operators and the "rural population" reported in the Population Census. This is a lower bound estimate of the true number of hired laborers and unpaid family workers. [9] Number of all oxen, mules, and horses, as no estimate of work animals is given in the 1930 Census. [10] Includes only plows, seeders, scythes, threshers, carts, trucks, and tractors. [11] Includes "...seeds, repairs, taxes, contributions, etc." The 1930 report was inflated by the ratio of the 1940 report to the 1930 index of money wages paid in agriculture.

Source: *(34)*.

The impact of land reform on the effective supply of farm labor partly supports this inference. Data shown in table 31 may understate the effective increase in number of farm operators. In constructing those data, it was assumed that the newly created ejidatarios would work the same number of days as hired laborers for the same real return. The 1940 Mexican Ejido Census, however, reported that ejidatarios worked an average of about four times as many days a year as did the average hired laborer (189 versus 48 days). Therefore, the number of full-time owner operators might have actually increased 5.5 percent (table 32) instead of 3.4 percent (table 31).

Table 32.—Number of farmworkers in Mexico under alternative sources, 1930 and 1940

Item	Owner-operator class			Total
	Ejidatarios	Private farmers—		
		With 1-5 hectares	With over 5 hectares	
	Thous.	*Thous.*	*Thous.*	*Thous.*
1930:				
Census[1]	537	576	282	1,395
Table 31	97	104	282	483
"Revised"[2]	392	104	282	778
1940:				
Census[1]	1,223	929	290	2,442
Table 31	220	166	290	676
"Revised"[2]	893	166	290	1,349

[1] Direct Census number. [2] Taking account of information in Ejido Census.

The difference in the two estimates would account for a large part of the 1930-40 apparent increase in total factor productivity. Correspondingly, a substantial economic gain would be attributed to land reform, stemming from the assignment of agricultural laborers to the category of owner-operators.

Two considerations would lead to acceptance of the Ejido Census report on days worked. First, data in table 33 show that real wages paid farmworkers decreased during the Cardenas era (1934-39); at the same time, output was expanding. Other things equal, this is consistent with a shift in the effective supply of labor induced by land reform. While the evidence for the Calles years (1925-28) is less conclusive, real wages also appear to have declined between 1927 and 1928, while output increased slightly. Furthermore, 1927 was the pinnacle of Calles reforms.[24]

Second, acceptance of the reported number of days worked is consistent with references in the Mexican literature of the period to life on the old haciendas

Table 33.—Selected indexes of farm wages and prices, Mexico, 1910 and 1925-40

Year	Farm wages	Prices	Real wages
1910	100	100	100
1925	385	225	171
1926	465	230	202
1927	595	247	241
1928	586	258	227
1929	457	233	196
1930	341	209	163
1931	347	202	172
1932	320	172	186
1933	306	170	180
1934	499	214	233
1935	533	235	227
1936	450	237	190
1937	353	237	149
1938	n.a.	n.a.	n.a.
1939	n.a.	n.a.	n.a.
1940	422	272	155

Source: *(13)*. Prices are "retail prices of basic subsistence commodities."

(5,40.) The misfortune of farm labor working on these large-scale units is frequently mentioned. The reward was in the pay, not the task. The work itself was monotonous, routine, and the "hacendado" made it burdensome. Thus, new farm operators may have been so keen on improving their conditions of life that they worked more days each year.[25]

The above inferences regarding the impact of land reform on 1930-40 total factor productivity are partially offset by at least two observations.

One is that the actual change in gross farm output during the 1930's was probably somewhat under 4.0 percent a year. Both 1929 and 1930 were abnormally poor years for crop and livestock production, while 1940 was an abnormally good year for both sectors. Therefore, if the rate of increase in farm output were based on the 1930-40 trend, rather than the 2 Census years, 1930 and 1940, the growth rate of agricultural production would be reduced from 4.0 to 3.0 percent a year (see table 8).

Also calling into question land reform's contribution to a gain in total factor productivity during 1930-40 is evidence on the viability of large-scale farms. For example, it is seen in table 34 that no significant change occurred in the distribution of private farmland after the intensive reforms of the 1930's. As land reform expropriated over 20 million hectares from the affectable size classes of farms during 1940-65, it is appreciated that entry of large-scale farms progressed at

[24] The index (1900 = 100) of gross farm output was 126, 136, 132, 138, 119, and 107 for the 1925-30 period (60). Between 1934 and 1940 the index was 125, 132, 141, 140, 151, and 155. Land area distributed between 1925 and 1928 (1,000 hectares) was 702, 751, 891, and 609.

[25] Apart from these considerations, there is the evidence of the production functions estimated from the 1960 Census data. They show that output per unit of total input would have risen had private sector units been converted into ejido units in that year. App. A expands on this point. Its relevance to 1930 is clearly open to question.

Table 34.—Cumulative percentage distribution of farms and land in the private sector, by land size, Mexico, 1930-60[1]

Hectares	1930		1940		1950		1960	
	Farms	Land	Farms	Land	Farms	Land	Farms	Land
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Less than 5	67.5	0.7	76.1	1.1	73.5	1.2	66.7	1.0
5 - 9	76.7	1.2	82.2	1.7	80.1	1.9	73.7	1.6
10 - 49	90.1	3.4	92.7	4.8	91.9	5.6	88.8	5.2
50 - 99	93.2	5.0	95.3	7.2	95.0	8.6	93.1	8.6
100 - 199	95.4	7.2	97.2	10.5	97.1	12.5	96.2	13.1
200 - 499	97.4	11.8	98.6	16.2	98.6	18.9	98.1	19.7
500 - 999	98.3	16.4	99.1	20.7	99.1	24.0	98.9	25.6
1,000 - 4,999	99.5	34.0	99.7	36.3	99.7	40.1	99.6	43.2
5,000 and over	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Gini Coefficient[2]	0.76		0.75		0.73		0.73	

[1] Land includes pastureland, cropland, woods, and marginal farmland which is not classified among the other three types of farmland. The 1960 distribution diverges slightly from that shown in table 3, which includes only pastureland and cropland.

[2] The Gini Coefficient was computed as $1 - \frac{\Sigma L_i}{\Sigma F_i}$, where L_i is the cumulative percentage of land and F_i the cumulative percentage of farms in the i-th size class. The more the distribution of land conforms to the distribution of farms, the lower is its value. A zero value corresponds to "perfect equality."

Source: Based on data from *(34)*.

rapid rates despite the threat of expropriation. In fact, the number of farms in excess of 1,000 hectares increased from 16,825 in 1940 to 22,600 in 1960. Data of table 35, restricted to just 2 census years, do not contradict the inference of these observations—namely, that the long-run viability of large-scale farm enterprises indicates they are not at a comparative disadvantage with smaller scale units. Thus, their division into smaller units during the 1930's should not have increased total factor productivity.

Long-Run Impacts of Land Reform

The hastening of "social justice" in rural areas of Mexico was an important long-run impact of land reform. Whetten's description of the new ejidatarios gives this conclusion its appropriate meaning.

> Everywhere they reported that they are enjoying personal freedom that was nonexistent previously. They might be living in the same shacks, subsisting on the same type of diet (with, perhaps, some improvement in quantity) wearing the same types of clothes, and drinking the same polluted water; but at least they are not abused by the landlord or kept in perpetual debt slavery, or hunted down by the "rurales" if they try to escape. They are not required to purchase their food and clothing through the "tienda de raya" (hacienda store). There is now no fear of arbitrary arrest and punishment without trial; "ley fuga" is no longer the dreaded fate of those who incur the displeasure of government officials *(47,* p. 571).

Table 35.—Cumulative percentage distribution of farms and production in the private sector, by value of crop production, Mexico, 1950 and 1960

Value of crop production 1960 pesos	1950		1960	
	Farms	Production	Farms	Production
	Percent	*Percent*	*Percent*	*Percent*
Under 1,000	60.1	4.4	56.3	3.0
1,000 - 4,999	78.9	12.4	85.0	11.3
5,000 - 24,999	96.5	36.4	95.6	26.5
25,000 - 49,999	98.2	47.0	97.6	35.1
50,000 - 99,999	99.2	59.5	98.8	45.5
100,000 - 499,999	99.6	69.0	99.8	72.3
500,000 and over	100.0	100.0	100.0	100.0
Gini Coefficient[1]	0.48		0.54	

[1] The Gini Coefficient was computed as $1 - \frac{\Sigma P_i}{\Sigma F_i}$, where P_i is the cumulative percent of production and F_i the cumulative percent of farms in the i-th size class. The more the distribution of production conforms to the distribution of farms, the lower is its value. A zero value corresponds to "perfect equality."

Source: Based on data from *(34)*.

Life on the remaining haciendas also changed. Today, there is little to distinguish them from other types of farm units. Apart from their size, vestiges of the Colonial and prereform periods have been eliminated. Social justice has been installed.

On the economic side, there are two questions of relevance to an assessment of the long-run impacts of land reform: First, what was the comparative production performance of the ejido sector after 1940? Second, at what additional cost or benefit was this performance obtained?

With respect to production, there are a number of reasons that might lead one to expect that the long-run growth rate of the ejido sector was below average. As noted earlier, the size of the land parcels given ejidatarios was small. Also, the quality of the land they received was low. Expropriated owners could retain the best sections of their farms. Further, ejidatarios were not given recourse to rental, sale, or mortgage arrangements. Finally, the technical and managerial backgrounds of ejidatarios were inferior—they generally had no experience in entrepreneurship before receiving land.

Available data, however, do not suggest that these adversities mattered greatly. Although annual data on aggregate output and input use are not available for the ejido and private sectors separately, the interpolated data of table 36 show that during 1940-62, the growth of crop production in the ejido sector lagged behind that of the private sector by only about 1.0 percent a year. During 1954-62, growth rates of crop production and crop yields were actually higher in the ejido sector.

Thus, while the Mexican ejido structure has not been as effective as the SRH irrigation districts in raising agricultural production, it was by no means a complete failure after 1940. One reason for this is most apparent: ejidatarios have received their fair share of the benefits of irrigation developments. This point has been well documented by the Mexican Agricultural Census and the Secretariate of Water Resources and was referred to in chapter II. Data for 1955 show that 75 percent of the

Table 36.—Indexes of land area harvested and crop yields, ejido and private sectors, Mexico, 1940-62[1]
(1960=100)

Year	Ejido sector		Private sector	
	Cropland harvested	Yields	Cropland harvested	Yields
1940	65.1	68.9	31.7	55.9
1941	72.0	66.6	34.0	55.6
1942	78.3	68.5	35.8	67.1
1943	88.7	65.7	41.6	70.1
1944	83.4	68.3	38.6	82.6
1945	87.0	71.3	41.5	87.3
1946	91.6	73.7	43.0	91.6
1947	88.7	79.1	46.2	92.1
1948	94.5	79.1	44.8	107.5
1949	97.3	81.8	51.7	105.7
1950	97.6	76.8	59.8	103.8
1951	99.7	74.8	64.5	101.2
1952	96.4	74.8	64.7	99.4
1953	97.3	79.2	63.3	103.7
1954	97.6	80.2	74.4	99.0
1955	101.9	82.3	90.5	88.2
1956	99.3	84.8	89.5	97.1
1957	92.0	92.1	96.4	101.3
1958	94.2	97.3	97.1	107.1
1959	99.3	97.1	98.7	101.7
1960[2]	100.0	100.0	100.0	100.0
1961	103.6	98.0	92.0	115.5
1962	96.1	107.1	102.8	115.6
	Percent	*Percent*	*Percent*	*Percent*
Compound rate of growth				
1940-53	2.1	2.1	3.9	3.1
1954-62	1.9	2.4	1.7	2.1
1940-62	2.1	2.4	2.7	2.9

[1] Based on Mexican Agricultural Census data by sector for 37 principal crops and interpolated annually using procedures outlined in App. B. The interpolating series for a sector included only those crops for which production was equal to or greater than 75 percent of total production. [2] Land area harvested was 5.5 million and 6.6 million hectares respectively for the ejido and private sectors. Output per unit of land harvested was US$86 for ejidatarios and US$103 for all other farmers.

farmers in SRH districts were ejidatarios and that they worked 41 percent of all irrigated cropland. In 1960, 42 percent of the cropland in irrigation districts was farmed by ejidatarios, who represented about two-thirds of all farmers. The ejido sector received an average of 47 percent of all water distributed during 1948-62. An interesting result is that ejidatarios cannot be characterized as "subsistence farmers" producing a disporportionate share of corn, beans, and chile. Although the small size of their land parcels has precluded entry into livestock production, the 1960 Agricultural Census shows that export crops represented about equal shares of ejido and private sector crop production (table 37).

Table 37.—Shares of crop production in selected export crops, ejido and private sectors, Mexico, 1960

Crop	Ejido sector	Private sector
	Percent	*Percent*
Bananas, roatan	1.2	0.9
Coffee, cereza	4.4	8.9
Cotton	10.9	14.7
Garbanzo	0.6	0.1
Garlic	0.1	0.2
Henequen	5.1	1.4
Sugarcane	0.9	1.7
Tobacco	1.5	0.3
Tomatoes, red	2.6	2.1
Total	27.3	30.3

Source: *(34)*.

A second reason for the ejido's production performance is that most of its supposed adversities are of a structural nature—they are inherent conditions, invariant through time. Although causing important differences in the organization of production between the two sectors at any point in time, they have not prevented the ejidatario from responding in the same ways to many of the same forces of change that increased output in the private sector during 1940-65. Production on ejidos has always been at somewhat different levels than that of the private sector, but the rates of change have nonetheless been similar.

Although structural adversities of ejidos have not greatly affected production performance, they have affected the cost of that performance in one important way. The productivity of the family labor input on ejidos is lower than on other farms. The reason for this relates to the limitation on rental or sale of ejido land imposed by the Agrarian Code. The nonalienation laws have meant that the individual ejidatario would willingly remain in agriculture while receiving a return to his labor which was well below his best off-farm alternative. As long as the combined return from land and labor exceeded the alternative wage rate available, staying with the ejido was indicated.[26]

[26] App. A expands on this point.

Two other factors have aggravated the labor adjustment problem of ejidatarios. One is that off-farm employment opportunities for ejidatarios are limited. Neighboring farmers outside the SRH districts are themselves ejidatarios. Also, the old haciendas were generally isolated, self-sustaining villages. The ejido village has retained this character and employment outside agriculture is limited to specialized crafts and trades. Packinghouses, warehouses, processing plants, and the like are in major cities some distance away.

Another factor has been the ejidatarios' lesser ability to avail themselves of off-farm employment opportunities that do exist. Data in table 38 show the years of schooling completed by ejidatarios to be generally below Mexico's rural average.

Table 38.—Comparative level of schooling of farm operators, Mexico, 1965[1]

Years of schooling completed	Private owner-operators	Ejidatarios	All farm operators[2]
	Percent	*Percent*	*Percent*
0	2.8	10.1	7.7
1 - 3	24.3	47.1	38.7
4 - 6	40.9	37.8	38.9
7 - 9	13.1	3.3	7.1
10 - 12	9.7	1.3	4.2
More than 12	9.2	0.4	3.4
Total	100.0	100.0	100.0
	Years	*Years*	*Years*
Average years completed[3]	6.2	3.4	4.4

[1] Based on a sample of 5,551 farmers attending "Field Days" in Mexican experiment stations. This sample is more heavily weighted with "good farmers" than the general population. However, similar summary data for the population of farmers are unavailable. [2] Includes share-croppers, renters, and "colonos," as well as ejidatarios and private owner-operators. [3] Excludes 17 "operators" who reported more than 17 years of schooling.

The low return to the family labor input in the ejido sector would lead to a judgment that land reform has been costly, or uneconomic. However, on a broader view of productivity—one which looks at all factors of production—land reform appears to have been output-increasing. From the production function estimates made on 1960 data, it is concluded that Mexican farm output would increase were the structure of production found among ejidatarios imposed on farms in the private sector.[27]

Thus, it is evident that land reform has led to mixed results: while probably increasing total factor productivity, it has reduced returns to the labor input. If a choice had to be made as to whether to continue land reform on a large scale on the basis of these mixed results, it would be difficult to make, since a sacrifice of labor returns would compromise the social spirit of Mexican land reform.

[27] See app. A.

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APPENDIX A.--A CROSS-SECTION EXPLANATION OF PRODUCTIVITY GAINS

Introduction

For the cross-section analysis of productivity gains, an input index was constructed that incorporates specifically the effects of land reform and irrigation policies on input productivity. Aggregate weights were estimated for four production functions from unpublished county-level data of the 1960 Mexican Agricultural Census--one function each for private and ejido groups outside and inside SRH irrigation districts. Equation (1) is the production relation for the j-th group and is basically of the Cobb-Douglas form:

$$(1) \quad \text{Log } Q_j = \sum_o \delta_{ij} \text{ Log } V_{ij} + u_j$$

All output and input variables were measured as averages per farm in each county and defined as follows:

- Q: Value of gross farm output
- V_o: A constant, $\text{Log}_e V_o = 1.0$
- V_1: Purchased inputs (noncapital; that is fertilizers, seeds, insecticides, and irrigation water)
- V_2: Family labor
- V_3: Hired labor
- V_4: Land
- V_5: Livestock capital
- V_6: Power and implements
- u_j: A random, independently distributed variable with zero mean and finite variance
- j=1: Private sector, outside SRH districts (group 1)
- j=2: Ejido sector, outside SRH districts (group 2)
- j=3: Private sector, inside SRH districts (group 3)
- j=4: Ejido sector, inside SRH districts (group 4)

The parameters (δ_{ij}) of these four relations were estimated by simple least squares regression procedures.

With constant returns to scale, competitive equilibrium, and an absence of group-specific effects of public policies, the four parameters estimated for a particular input in equation (1) should be equal and correspond identically to the weight used in chapter 4 in the conventional index of total input. In particular, an input's weight (δ_{ij}) in any group would equal its share of that group's total production costs; that is, the ratio of the costs of the input's use to total production costs.

However, if average production costs are not constant for every scale of farm enterprise, or if the value-marginal productivity of an input diverges from its market price by reason of disequilibrium, parameters estimated in equation (1) for an input would not necessarily equal each other or the corresponding 1960 factor share. Differences could stem from effects of public policies. If irrigation developments have lowered relative prices of purchased inputs, induced adoption of an irrigation technology, and enhanced

the quality of purchased inputs, larger coefficients would be anticipated on purchased inputs and power and implements for farms inside SRH districts. Similarly, an effective subsidy to family labor use, resulting from nonalienation provisions of the Agrarian Code, should lower estimated coefficients for family labor on ejido farms.

In the following pages, data sources are discussed, variables are defined, and possible shortcomings of those definitions are outlined. Then, basic results obtained from the estimated aggregate production functions are shown. Finally, implications of the production function estimates are presented for measurement of sources of productivity growth through time and differences in productivity between groups as of a point in time.

Data and Variables

Data used to estimate production functions were tabulated from over 1,500 county-level summaries of the 1960 Mexican Agricultural Census, encompassing the year beginning May 1, 1959. The summaries contained input and output data on a wide range of variables for three tenure classes: private farms exceeding 5 hectares, private farms of 5 hectares or less, and ejido farms. Information on certain input variables for the small private farms was not obtained by the Census, however. Thus, such units were excluded from the private sector in the analysis. This is not a serious omission, as small private farms accounted for only about 5 percent of the value of gross farm output and operated from slightly less than 1 percent of all Mexican farmland in 1960.

Since the Census did not report output and input data separately for SRH and non-SRH districts, counties in groups 3 and 4 were considered irrigation counties if they contained one or more SRH districts in 1960. Table A-1 summarizes the more detailed data developed in the study for the purposes of identifying SRH counties.

Output data included 62 crops and all dairy and meat products except those of poultry. Output was defined explicitly by the Census as production, not sales--for which data are also reported. It was the intention of the Census to apply "farm gate" prices to outputs in calculating the value of gross farm production.

On the input side, 54 variables were tabulated from the summaries for both ejido and private sectors. Their aggregation into the six input categories of the production functions is summarized below; the question of omitting rainfall as a variable is also discussed.

Noncapital Purchased Inputs

The Census defined the value of noncapital purchased inputs as the total cost of purchased fertilizers, insecticides, seeds, water, and "other expenses" (items such as livestock vaccines and seed innoculents), plus interest costs on investment in farm-owned irrigation and water control facilities. 1/ (Noncapital purchased inputs will hereafter be referred to as purchased inputs.) Farm-produced organic fertilizers were not reported by the Census. However, SRH estimates show that the gross weight of organic fertilizer use in irrigation districts is only 6 percent of that of chemical fertilizers (38).

Because of a presumed agronomic complementarity between irrigation and other purchased inputs in Mexican agriculture, first-round estimates of production functions were used to explore the possibility that a simple linear aggregation of purchased inputs could be improved by allowing for finite elasticities of substitution between water and other purchased inputs. Results of the experiment, discussed on pages 74-75 demonstrated that the county-level Census data were insensitive to the method of aggregating this input category.

1/ A 15-percent interest rate was applied here and elsewhere in this study to obtain interest costs.

Table A-1.--Mexico's SRH irrigation districts, by state location and number of counties, 1960

District	State	Number of counties	District	State	Number of counties
Acuna Falcon	Coahuila	4	Rio Colorado	Baja California	1
Palestina	Coahuila	2			
Guadalupe Victoria	Coahuila	1	Santo Domingo	Baja California T.	2
Region Lagunera	Coahuila	5			
Don Martin	Coahuila	1	Ahuacatlan	Nayarit	1
			Santa Rose	Nayarit	1
San Buenaventura	Chihuahua	2	Tetitlan	Nayarit	1
Ciudad Delicias	Chihuahua	6	Valle De Banderas	Nayarit	1
Ciudad Juarez	Chihuahua	3	Rio San Pedro	Nayarit	1
			Mecatan	Nayarit	1
Region Lagunera	Durango	8	Miramar	Nayarit	1
Estado De Durango	Durango	1	Rio Santiago	Nayarit	1
Don Martin	Nuevo Leon	1	Moscarito	Sinaloa	1
Alto Rio San Juan	Nuevo Leon	3	Guasave	Sinaloa	2
Las Lajas	Nuevo Leon	1	Culiacan	Sinaloa	1
Acuna Falcon	Nuevo Leon	1			
			Rio Altar	Sonora	3
Bajo Rio San Juan	Tamaulipas	4	Colonias Yaquis	Sonora	3
Rio Frio	Tamaulipas	1	Rio Yaqui	Sonora	5
Acuna Falcon	Tamaulipas	2	Rio Mayo	Sonora	3
Llera	Tamaulipas	1	Costa de Hermosillo	Sonora	1
Bajo Rio Bravo	Tamaulipas	3	Rio Colorado	Sonora	1
Purificacion	Tamaulipas	1			
Xicothencatl	Tamaulipas	1	Estado de Colima	Colima	5
Trujillo	Zacatecas	1	Cacahoatan	Chiapas	2
Tlatlenango	Zacatecas	3	Rio Blanco	Chiapas	2
			Suchiate	Chiapas	1
Campeche	Campeche	6			
			Ayutla	Guerrero	1
Actopan	Veracruz	2	Coyuca De Benitez	Guerrero	1
La Antigua	Veracruz	5	Ciudad Altamira	Guerrero	3
Rio Panuco	Veracruz	3	Laguna De Tuxdan	Guerrero	1
			Coyuquilla	Guerrero	1
Yucatan	Yucatan	27	Quechultenango	Guerrero	1
			San Luis de la Loma	Guerrero	1

Continued--

Table A-1.--Mexico's SRH irrigation districts, by state location and number of counties, 1960--continued

District	State	Number of counties	District	State	Number of counties
San Luis San Pedro	Guerrero	1	Arroyozarco	Mexico	3
Pabellon	Aguascalientes	3	Altacomulco	Mexico	2
Alto Rio Lerma	Guanajuato	15	Toxi	Mexico	2
Tulancingo	Hidalgo	2	Barrio de Santo Domingo	Mexico	1
Tula	Hidalgo	15	San Bartolo Del Llano	Mexico	1
Lxmiquilpan	Hidalgo	1	San Pedro de los Banos	Mexico	1
Meztitlan	Hidalgo	1	Santo Domingo de Guzman	Mexico	1
Actlan de Juarez	Jalisco	2	Tepetitlan	Mexico	2
Ahualulco	Jalisco	2	Xiolotepec	Mexico	2
Ameca	Jalisco	4	San Felipe Santiago Endoge	Mexico	1
La Magdalena	Jalisco	3	Cuendo	Mexico	2
Autlan y El Grullo	Jalisco	2	El Tigre	Mexico	1
Rios Lerma, Zula Y Santiago	Jalisco	3	El Mortero	Mexico	1
Estado de Colima	Jalisco	1	La Jordana	Mexico	1
Jamay	Jalisco	1	Morelia y Querendaro	Michoacan	7
El Cuarenta	Jalisco	1	Cienaga de Chapala	Michoacan	9
El Fuerte	Jalisco	1	Zamora	Michoacan	6
San Miguel El Alto	Jalisco	1	Zacapu	Michoacan	3
Amatitlam	Jalisco	1	Tuxpan	Michoacan	3
Belem del Refugio	Jalisco	1	Tzurumutaro	Michoacan	2
Tizapan El Alto	Jalisco	1	Estado de Morelos	Morelos	20
Villa Guerrero	Jalisco	1	Valsequillo	Puebla	15
Yahualica	Jalisco	1			
La Colonia	Jalisco	1			

The author gratefully acknowledges the cooperation and assistance of the Mexican Secretariate of Water Resources, Ing. Luis de Lomia, and Ing. Mateo Vasquez Morales in preparing these data.

This conclusion is not inconsistent with another finding that the "package hypothesis," as extreme agronomic complementarity has been called, is crop-specific and unimportant for major crops. Examination of over 3,000 corn and wheat field trials published by the Rockefeller Mexican Program and the National Institute of Agricultural Research produced evidence of strong "interactions" between certain purchased inputs in the case of wheat production, but none emerged for the more important case of corn. Results are discussed later in this appendix (pp. 75-79).

Labor Inputs

Included in labor inputs are (1) family labor (farm operators and unpaid family workers) and (2) hired labor measured on an equivalent, full-time basis. In certain estimates, the two categories were merged.

Full-time hired labor was derived by dividing the wage bill by 12 times a composite state wage rate (table A-2) for May 1960, calculated from a special publication of the 1960 Mexican Census of Population. The composite May wage reflects a near full-employment rate as only cotton, among Mexico's major crops, is not in a planting or harvesting stage during that month.

No similar adjustment could be made for unpaid family laborers or farm operators. Using the stock of family laborers implies that quality classes (for example, age and sex) are either homogeneous in productive capacity or move in fixed proportion over the cross section and that employment rates are not influenced by variations in wage alternatives. That is, the supply curve of the flow of family labor services is wage inelastic. The latter proposition is consistent with the definition of family labor as a category of workers who--once in the farm labor force--work for the farm until the job is done.

Land

Land was measured in terms of the commercial, or market, value of all cropland and pastureland in farms. 2/ The Census defined cropland as the sum of cropland harvested, cropland planted but not harvested, cropland multiple-cropped, and cropland idle.

While superior to the quantity measure of farmland, where quality is so heterogeneous, specification of the land input in terms of stock values requires that land rents--the "true" measure of the land input--be a constant proportion of the price of farmland over the cross section. This in turn requires a constant difference between "the" rate of interest (R_I) and the rate of expected future capital gains on land (R_G). Even if interest rates are constant, differences in R_G could be reasonably anticipated. In general, results of omitting R_G will be to bias upwards the estimated parameter for the land input, provided that either expectations are strongly (and positively) influenced by land prices, $R_G > R_I - R_G > 0$, and the stock supply elasticity of the input is "small," 3/ or (obviously) $R_I - R_G < 0$.

2/ Wherever "value" figures are reported on stocks by the Census, they correspond to "market value."

3/ Define the relation between output, Q, a stock value, $V^*_4 = W_4$, V_4, W_4 being the price per unit of the stock, and another input, V_1, by

$$\begin{aligned}\text{Log } Q &= a_1 \text{Log } V_1 + a_4 \text{Log } V^*_4 + a_4 \text{Log } (R_I - R_G)\\ &= a_1 \text{Log } V_1 + a_4 \text{Log } V^*_4 - a_4 R_G, \text{ approximately, for}\end{aligned}$$

$|R_G/R_I| 1.0$, if R_I is constant and all variables are measured as deviations from their means. If R_G is omitted from the regression, then

$$E(\hat{a}_4) = a_4(1.0 - \frac{1}{R_I} Z_{R_G} \text{ Log } V_4),$$

where Z is a partial regression coefficient obtained from the regression of the omitted variable on all included variables. This expression can be rewritten as (continued)

Livestock Capital

Included are interest costs on the value of bovine, sheep, pigs, and goats of all ages held on farms for either meat or milk production, plus purchased feed for such animals. The feed expense component was derived by multiplying "total feed expense" by the share these animals represented of the value of all livestock, including poultry and work animals. Farm-produced feeds consumed by livestock were not included by the Census in "total feed expense."

The Census reports livestock in four surveys: two for animals on each type of private farm, one for ejido units, and one for animals in villages. About a fifth (21 percent) of all animals by value fell into the survey on animals in villages and could not be included in "livestock capital" because there was no basis for allocating them between tenure groups. Most animals in villages--aside from milk cows--were there to be marketed, and marketings, as a proportion of measured herd size, may have been positively related to the included livestock variable by reason of less on-farm consumption on larger livestock ranches. Thus, this omission could bias upwards the estimate of the livestock capital coefficient in the production functions.

Two considerations mitigate somewhat the seriousness of the bias: (1) Because the four surveys were taken independently, some part of livestock reported in villages may have been (systematically) included in the reports of livestock on farms; and (2) most livestock in villages are milk cows and those animals comprise a large share of the value of the herd on small, private farms. Since village units have been excluded, problems of double-counting and/or omitting livestock are less serious than had such units been included. 4/

Power and Implements

Power and implements includes the costs of gasoline, oil and lubricants, feed for work animals, and machine and work animal hire, plus interest on the value of all machinery, implements, cottage-type tools, and work animals. Feed expense for work animals was calculated by using a method analogous to that described for feed expense included in the livestock capital input.

Rainfall: An Omitted Variable?

Although rainfall and temperature are quite variable over the cross section, they would not be expected to influence estimates in "normal" years. Farmers generally plan input use before weather is known, making input employment weather-independent.

Exceptions occur in years of abnormal weather, when plans for the use of more variable factors of production may be altered to compensate for unseasonal rainfall or temperature. If, however, rainfall and temperature are included as variables to prevent bias, weather could be effectively double counted since part of it should already be embodied in the quality (price) of location-specific inputs, like land. While double counting could be avoided by measuring weather in terms of its deviations from "normal" in each county, the costs of obtaining such data are prohibitive.

$$E(\hat{a}_4) = a_4 \left\{1.0 - \frac{R_G/R_I}{R_I \, \eta_{WR} \, R_G(1 + \eta_{WR}) + (R_I - R_G)\eta_{VW} \, \eta_{WR}}\right\}$$

$$\eta_{WR} = \frac{\delta W_4}{\delta R_G} \, \frac{R_G}{W_4} \text{ and } \eta_{VW} = \frac{\delta V_4}{\delta W_4} \, \frac{W_4}{V_4}$$

4/ These points have been discussed in (48).

Table A-2.--Farm and nonfarm wage rates per month, Mexico, 1950 and 1960

Region and state	1950 Farm wage	1950 Nonfarm wage	1950 Farm as percentage of nonfarm wages	1950 Difference	1960 Farm wage	1960 Nonfarm wage	1960 Farm as percentage of nonfarm wages	1960 Difference
	--- Pesos ---		Percent	Pesos	--- Pesos ---		Percent	Pesos
North............	151	265	0.57	114	398	786	0.51	388
Coahuila.......	154	287	0.54	133	454	742	0.61	288
Chihuahua......	180	285	0.63	105	538	876	0.61	338
Durango........	148	232	0.64	84	375	851	0.44	476
N. Leon........	148	266	0.56	118	437	837	0.52	400
S. L. Potosi...	133	217	0.61	85	255	586	0.61	331
Tamaulipas.....	162	298	0.54	136	462	815	0.57	353
Zacatecas......	132	192	0.69	60	283	552	0.51	269
Gulf.............	147	248	0.59	101	291	709	0.41	418
Campeche.......	241	312	0.77	71	377	627	0.60	250
Q. Roo.........	231	298	0.77	67	388	896	0.43	508
Tabasco........	137	213	0.65	75	323	731	0.44	408
Veracruz.......	143	261	0.55	117	333	744	0.45	411
Yucatan........	147	198	0.75	50	258	583	0.44	325
Pacific North....	198	331	0.60	133	496	999	0.50	503
B. Calif.	357	546	0.65	189	802	1,298	0.62	496
B. Calif. T. ..	249	331	0.75	81	524	855	0.61	331
Nayarit........	140	208	0.67	68	389	650	0.60	261
Sinaloa........	156	263	0.59	106	463	858	0.54	395
Sonora.........	192	308	0.62	117	608	951	0.64	343
Pacific South....	132	193	0.68	61	296	572	0.52	276
Colima.........	172	229	0.75	57	441	714	0.62	273
Chiapas........	136	195	0.70	59	321	561	0.57	240
Guerrero.......	152	213	0.71	61	288	613	0.47	325
Oaxaca.........	108	169	0.64	230	261	515	0.51	254
Central..........	135	255	0.53	120	346	814	0.43	468
Ags. Calientes	137	239	0.57	102	361	589	0.61	228
D. F.	162	293	0.55	130	973	944	1.03	-29
Guanajuato.....	153	195	0.78	43	301	586	0.51	285
Hidalgo........	129	186	0.69	58	305	508	0.60	203
Jalisco........	158	221	0.71	64	379	701	0.54	322
Mexico.........	117	185	0.63	67	336	569	0.59	233
Michoacan......	132	191	0.69	60	315	518	0.61	203
Morelos........	134	215	0.62	81	387	693	0.56	306
Puebla.........	121	212	0.57	90	296	631	0.47	335
Gueretaro......	124	195	0.64	71	307	550	0.56	243
Tlaxcala.......	122	189	0.64	67	260	504	0.52	244
Mexico...........	145	258	0.56	113	354	800	0.44	346

Source: (35).

At an early stage of this study, an annual rainfall variable was constructed for each county for the Census year from reports made by 2,455 of Mexico's weather stations. Sensitivity of estimated input parameters was explored in the context of a "conventionally specified" aggregate production function; that is, one which pooled observations from the four production groups. An answer was sought to the following question: Does rainfall improve R^2 and produce significant changes in coefficients of the most valuable inputs?

Results are shown in table A-3. The difference between regressions 1 and 2 is solely a consequence of reducing the number of observations to include counties for which reliable estimates of rainfall could be made. 5/ Note that the estimated coefficient for land increased and that for purchased inputs decreased slightly. Differences between regressions 2 and 3 reflect the effects of introducing rainfall. Although the rainfall coefficient was statistically significant, R^2 was unaffected and no significant differences in estimated coefficients were found. Regression 4, compared with 3, demonstrates the effects of redefining the value of irrigated cropland in terms of the value of comparable unirrigated cropland. The significant decrease in the land coefficients is consistent with expectations based on earlier discussion. The fact that the coefficient for the rainfall variable became insignificant suggests that prices of unirrigated cropland do include "normal" rainfall effects. Regression 5, which omits rainfall, was estimated from the larger sample used for regression 1. As coefficients were affected only slightly, but in the same ways by moving from regression 4 to 5 as by moving from 2 to 1, the different estimates are taken to reflect primarily differences in the sample, not the omission of rainfall.

Therefore, it appears that rainfall was about "normal" in the Census year, that it is captured by specifying "correctly" the land input, and that rainfall-weather is not a variable omitted from the model.

Production Functions

Tables A-4 through A-7 present the main results obtained when production functions were estimated separately for the four groups. Regression 1 corresponds to a more conventional specification of the production process. Regression 2 demonstrates the effects of treating farm labor categories as distinct inputs. Regression 3 makes adjustments for differences in the composition of farm output, and 4 represents a synthesis of results obtained from 3. Results in column 5 of the four tables summarize estimates obtained from regression 4.

In most all specifications, significant differences were found between the estimated coefficients and the factor share weights used to calculate sources of growth within the framework of a conventional input index. In general, larger coefficients emerged for the high-growth inputs (for example, purchased inputs and power and implements) and smaller ones were assigned by the regression results to the low-growth factors, notably labor.

As expected, estimated coefficients for purchased inputs were higher in all specifications inside SRH districts. A similar conclusion holds for the power and implements input except in the case of private farms. The significance of the estimated coefficient

5/ The author, in consultation with staff of the Mexican Meteorological Service, defined "spheres of influence" for each station in terms of the counties its "weather" included. Reports of stations whose spheres included the same county were averaged in deriving that county's rainfall. For several counties, identical rainfall resulted by reason of geographic dispersion of reporting stations. There were 200 counties to which no weather station's sphere could be reasonably attached. The assistance of Luis and Mateo Vasquez Morales in tabulating these rainfall data is gratefully acknowledged.

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Table A-3.--Aggregate production function estimates used to explore the effects of rainfall in Mexico 1/

Independent variable	Regression equation 2/				
	1	2	3	4	5
Purchased inputs	0.117 (0.011)	0.092 (0.012)	0.093 (0.012)	0.131 (0.012)	0.154 (0.011)
Labor 3/	0.091 (0.018)	0.089 (0.019)	0.081 (0.018)	0.079 (0.019)	0.083 (0.018)
Land 4/	0.367 (0.012)	0.392 (0.013)	0.387 (0.013)		
Adjusted land 5/				0.347 (0.012)	0.328 (0.011)
Livestock capital	0.309 (0.009)	0.308 (0.010)	0.307 (0.010)	0.287 (0.010)	0.293 (0.009)
Power and implements	0.121 (0.013)	0.123 (0.013)	0.131 (0.014)	0.162 (0.014)	0.153 (0.013)
Rainfall 6/			0.044 (0.019)	0.019 (0.019)	
Sum of coefficients	1.005 (0.017)	1.004 (0.017)	0.999 (0.017)	1.006 (0.017)	1.011 (0.017)
R^2	0.801	0.796	0.796	0.790	0.797
Residual variance	0.326	0.332	0.332	0.342	0.334
Degrees of freedom	3,068	2,625	2,624	2,624	3,068

1/ Except as noted below, based on 1960 weather station reports.
2/ The first number in each cell is the estimated coefficient; the second is its standard error. Unless otherwise noted, variables are defined as in the text.
3/ Includes full-time man-years of family and hired labor.
4/ The value of the stock of pastureland and cropland per farm.
5/ The value of the stock of pastureland and cropland per farm; irrigated cropland is measured in terms of comparable prices for unirrigated cropland.
6/ Measured as the $\log_e$ of rainfall during the year beginning May 1, 1959.

Table A-4.--Results of four alternative specifications of production functions, private sector outside SRH irrigation districts (group 1), 1940-65

Independent variable	Regression equation 1/				
	1	2	3	4	5 2/
Constant	1.410 (0.054)	1.979 (0.075)	2.093 (0.121)	1.512 (0.087)	1.864
ρ			-0.525 (0.240)	0.901 (0.140)	
Purchased inputs	0.143 (0.016)	0.135 (0.016)	0.167 (0.023)	0.102 (0.015)	0.102
Family labor		0.191 (0.033)	0.106 (0.046)	0.112 (0.029)	0.112
Hired labor		0.193 (0.019)	0.317 (0.031)	0.237 (0.018)	0.237
All labor 3/	0.396 (0.033)	0.384 (0.036)		0.349 (0.033)	0.349
Land	0.211 (0.017)	0.161 (0.019)	0.264 (0.030)	0.418 (0.024)	0.161
Livestock capital	0.348 (0.013)	0.370 (0.013)	0.191 (0.021)		0.351
Power and implements	0.129 (0.017)	0.106 (0.017)	0.034 (0.026)	0.113 (0.015)	0.113
ρ*Land			-0.364 (0.055)	-0.658 (0.041)	
ρ*Livestock capital			0.721 (0.043)	0.899 (0.030)	
ρ*Purchased inputs			-0.199 (0.051)		
ρ*Family labor			-0.036 (0.111)		
ρ*Hired labor			-0.237 (0.053)		
ρ*Power and implements			0.131 (0.054)		
Sum of coefficients	1.227 (0.031)	1.156 (0.035)			1.076
R^2	0.735	0.735	0.812	0.794	
Residual variance	0.322	0.319	0.229	0.249	

1/ The first number in each cell is the estimated coefficient; the second is its standard error.

2/ Based on regression 4 results. The coefficients shown for livestock capital and land equal the estimated coefficients for these variables plus $\bar{\rho}$ times the estimated coefficients for the corresponding ρ* input variables, where $\bar{\rho}$ is the mean of $\bar{\rho}$ in the production group shown in table 16. All other coefficients in this column equal those in the preceding column.

3/ In regression 1, this variable entered as the sum of the full-time hired laborers plus family labor. In all other regressions it did not enter as an independent variable.

Table A-5.--Results of four alternative specifications of production functions, ejido sector outside SRH irrigation districts (group 2), 1940-65

Independent variable	Regression equation 1/				
	1	2	3	4	5 2/
Constant	1.197 (0.059)	1.862 (0.084)	1.822 (0.117)	1.508 (0.084)	1.883
ρ			0.131 (0.407)	1.557 (0.162)	
Purchased inputs	0.160 (0.018)	0.107 (0.018)	0.103 (0.025)	0.118 (0.016)	0.118
Family labor		-0.188 (0.026)	-0.087 (0.038)	-0.121 (0.024)	-0.121
Hired labor		0.157 (0.015)	0.169 (0.021)	0.154 (0.014)	0.154
All labor 3/	-0.055 (0.025)	-0.031 (0.024)		0.033 (0.022)	0.033
Land	0.410 (0.021)	0.343 (0.021)	0.428 (0.028)	0.488 (0.027)	0.270
Livestock capital	0.249 (0.018)	0.250 (0.017)	0.156 (0.024)		0.323
Power and implements	0.119 (0.021)	0.120 (0.020)	0.114 (0.027)	0.125 (0.018)	0.125
ρ*Land			-0.694 (0.091)	-0.886 (0.086)	
ρ*Livestock capital			1.083 (0.079)	-1.340 (0.058)	
ρ*Purchased inputs			-0.057 (0.079)		
ρ*Family labor			-0.030 (0.127)		
ρ*Hired labor			-0.119 (0.074)		
ρ*Power and implements			-0.059 (0.083)		
Sum of coefficients	0.883 (0.034)	0.789 (0.031)			0.869
R^2	0.579	0.616	0.706	0.690	
Residual variance	0.283	0.258	0.199	0.209	

See footnotes to table A-4.

Table A-6.--Results of four alternative specifications of production functions, private sector inside SRH irrigation districts (group 3), 1940-65

Independent variable	Regression equation 1/				
	1	2	3	4	5 2/
Constant	1.460 (0.115)	1.843 (0.191)	1.370 (0.291)	1.206 (0.230)	1.711
ρ			1.665 (0.892)	1.761 (0.525)	
Purchased inputs	0.229 (0.044)	0.233 (0.043)	0.153 (0.060)	0.287 (0.042)	0.287
Family labor		0.157 (0.077)	0.097 (0.109)	0.195 (0.075)	0.195
Hired labor		0.160 (0.055)	0.030 (0.081)	0.065 (0.058)	0.065
All labor 3/	0.217 (0.077)	0.317 (0.081)		0.260 (0.082)	0.260
Land	0.331 (0.037)	0.289 (0.044)	0.456 (0.065)	0.503 (0.054)	0.274
Livestock capital	0.183 (0.030)	0.190 (0.030)	0.229 (0.059)		0.145
Power and implements	0.085 (0.056)	0.047 (0.057)	0.127 (0.080)	0.048 (0.055)	0.048
ρ*Land			-0.778 (0.188)	-0.797 (0.150)	
ρ*Livestock capital			0.162 (0.115)	0.505 (0.078)	
ρ*Purchased inputs			0.454 (0.188)		
ρ*Family labor			0.264 (0.379)		
ρ*Hired labor			0.117 (0.245)		
ρ*Power and implements			-0.400 (0.232)		
Sum of coefficients	1.045 (0.069)	1.076 (0.074)			1.014
R^2	0.695	0.706	0.748	0.727	
Residual variance	0.354	0.343	0.303	0.321	

See footnotes to table A-4.

Table A-7.--Results of four alternative specifications of production functions, ejido sector inside SRH irrigation districts (group 4), 1940-65

Independent variable	Regression equation 1/				
	1	2	3	4	5 2/
Constant	1.839 (0.108)	2.050 (0.206)	2.451 (0.256)	1.960 (0.184)	1.975
ρ			-3.173 (1.643)	0.092 (0.563)	
Purchased inputs	0.209 (0.040)	0.202 (0.041)	0.109 (0.053)	0.137 (0.037)	0.137
Family labor		-0.276 (0.071)	-0.521 (0.116)	-0.041 (0.069)	-0.041
Hired labor		0.050 (0.041)	0.047 (0.055)	0.041 (0.037)	0.041
All labor 3/	-0.216 (0.054)	-0.226 (0.054)		0.000 (0.056)	---
Land	0.192 (0.036)	0.177 (0.037)	0.216 (0.041)	0.235 (0.043)	0.130
Livestock capital	0.071 (0.034)	0.077 (0.034)	0.101 (0.035)		0.231
Power and implements	0.222 (0.049)	0.202 (0.041)	0.310 (0.063)	0.227 (0.044)	0.227
ρ*Land			-0.466 (0.286)	-0.651 (0.265)	
ρ*Livestock capital			1.888 (0.233)	1.435 (0.203)	
ρ*Purchased inputs			0.135 (0.351)		
ρ*Family labor			2.730 (0.626)		
ρ*Hired labor			-0.198 (0.319)		
ρ*Power and implements			-1.057 (0.452)		
Sum of coefficients	0.478 (0.073)	0.432 (0.078)			0.725
R^2	0.547	0.551	0.711	0.649	
Residual variance	0.284	0.283	0.188	0.224	

See footnotes to table A-4.

on power in group 3 was uniformly low, possibly because many of the private farms irrigated by SRH were in a transitional stage in 1960--one which involved switching from cotton production to less power-intensive crops like corn and sorghum. The cotton "boom" peaked in Mexico around 1956 and one of the results may have been idle machinery in the census year.

Although ejidatarios inside SRH districts were likewise moving out of cotton, their power and implements input is less specialized, being more heavily weighted with "work animals." Thus, as the results suggest, they were able to pass through this transitional period without idling as much of the input.

Relatively low production function coefficients for labor pervaded estimates for all groups except group 1. The coefficient in regression 1 for that group, for example, is about equal to the factor share estimate of 0.38 used for all labor in chapter 4 (see table 15).

The reason for the generally smaller coefficients for "all labor" is highlighted by comparison of regressions 1 and 2. In regression 1, it was assumed that full-time equivalent hired labor substituted perfectly for family labor at the prevailing wage for all labor. Regression 2 relaxed this assumption. This change in specification did not alter results appreciably: the sum of the estimated labor coefficients for each group in regression 2 corresponds closely to those obtained in regression 1.

However, the division of the labor input did reveal two things: (1) that coefficients for hired labor estimated from the ejido sector observations are similar to those obtained for corresponding private farms; and (2) that the family labor input differs markedly between private and ejido sectors, which accounts for most of the difference in the "all labor" coefficients obtained in regression 1.

The negative sign of the estimated coefficients for family labor on ejidos (groups 2 and 4) survived several alternative specifications of regression 2. These included omitting unpaid family workers less than 15 years old and weighting unpaid family workers by factors which ranged downward to 0.25. Also, a "search and destroy" technique was carried out at one point which involved looking for particular regions in which the family labor input was most negative and excluding them from the estimation of regression 2. The most that came of these exercises was small, positive-valued coefficients for the ejido family labor input. 6/ However, their relatively large standard errors, combined with the ad hoc means by which they were derived, led to the conclusion that the estimates shown for regression 2 were the best the data would provide. They are consistent with a premium being assigned by ejidatarios to the income from their parcels they would forfeit were they to exit agriculture.

Regression 3 adjusts all functions for the effects of product composition by redefining the coefficient for the i-th input and j-th group in equation (1) as

$$(2) \quad \delta_{ij} = \alpha_{1ij} + (\alpha_{2ij} - \alpha_{1ij})\,\rho_j;$$

6/ This result is not associated with any particularly peculiar feature of the variance of the data on family labor in the ejido sector:

Variable	Parameter	Group 1	Group 2	Group 3	Group 4
Output	Std. Dev.	1.099	0.817	1.068	0.783
	Mean	2.704	1.067	3.120	1.454
Family labor	Std. Dev.	0.468	0.661	0.552	0.691
	Mean	0.727	0.583	0.667	0.658

where ρ_j is a variable equal to the ratio of livestock output to gross farm output. On pages 79-85, it is shown that, if livestock and crop outputs are produced subject to Cobb-Douglas production functions, corresponding parameters in those functions are not equal, and farmers preselect the ratios in which they will produce the two outputs. Equation (2) represents a reasonable modification of coefficients in an aggregate production function of the Cobb-Douglas form. The coefficient α_{1ij}, is then interpreted as the production parameter corresponding to the i-th input in the crop enterprise, while α_{2ij} is interpreted as the parameter for that input in the livestock enterprise. The crop parameter emerges from the regression as the coefficient on the variable Log V_{ij}; the livestock coefficient emerges as part of the coefficient, $\alpha_{2ij} - \alpha_{1ij}$, on the variable ρ*Log V_{ij}.

Results of regression 3 demonstrated that adjustment for product composition improved overall explanation in each group. Further, estimated coefficients were reasonable in terms of prior judgements about the probable intensities of use of each input in livestock and crop production. For example, significant and positive coefficients were attached to the adjusted livestock capital variable and negative coefficients uniformly appeared on the adjusted land inputs, indicating that the intensity of use of livestock capital is lowest in crop production, while the intensity of land use is highest in that enterprise. Results for power and implements and hired labor were less decisive, but did indicate that these inputs are used most intensively in crop production. The coefficients on the adjusted purchased inputs and family labor variables were generally insignificant.

Regression 4 synthesizes the main results of regression 3 by omitting those adjusted input variables whose estimated coefficients in the fuller version of the composition model (regression 3) were least stable and significant in the four groups. Also, the unadjusted livestock capital variable was excluded. In regression 3, the estimated coefficients for that input, evaluated at the mean of the data, clearly represented overestimates, exceeding 0.40 in three of the four groups. While this was not unanticipated, it appeared that errors were compounded by treating livestock capital like a crop-livestock input when--by definition--its intensity of use in crop production should be quite low. Regression 4 deals with this by defining "low" in terms of zero-valued coefficients for livestock capital in crop production.

The last two columns of table A-8 present summary statistics, based on regression 4, that can be compared directly with the factor share weights used earlier in the conventional index of total input. The second column corresponds to results that would have been obtained had the separate groups been pooled in a single regression (appropriate "dummy variables" being included to adjust for group differences in intercepts and coefficients), and had "aggregate" input elasticities in that pooled function been evaluated at the mean of the data. Results show that, in these terms, 86 percent of the cross-sectional variation in Mexican farm output is explained by the four group functions. The third column presents a weighted average of the coefficients in regression 4, where the weight for a group corresponded to its share of the total value of gross farm output reported in the county data. These coefficients would represent the relevant "aggregate" elasticities of production if employment of an input in each group changed at the same rate through time. The fact that the two columns of coefficients are so similar merely indicates that (proportional) representation of a group in the county-level data corresponded closely to its share of aggregate output.

Implications for Cross-Sectional Differences in Productivity

Before production function results were applied to the time series data on inputs, it was established whether apparent differences between group production functions were statistically significant. Were differences not significant, relevant weights to be applied to input changes through time would be merely those estimated for the reference group, group 1. It would follow that public policies had not altered the structure of Mexican agricultural production.

Table A-8.--Three "summary" measures of agricultural input weights, Mexico, 1940-65

Input	"Factor share" weights 1/	"Aggregate" weights based on regression 4: "Simple" average 2/	"Aggregate" weights based on regression 4: "Product share" average 3/
Purchased inputs	0.071	0.126	0.146
Family labor	0.301		
(On small, private farms)	(0.093)		
(On other farms)	(0.208)	0.015	0.050
Hired labor	0.078		
(On small, private farms)	(0.007)		
(On other farms)	(0.071)	0.175	0.159
All labor	0.379	0.190	0.209
Land	0.291	0.211	0.206
Livestock capital	0.190	0.314	0.290
Power and implements	0.069	0.121	0.117
Sum	1.00	0.963	0.968
R^2		0.857	
Residual variance		0.237	

1/ Calculated from data shown in app. B, pp. 105-106.
2/ A weighted sum of the individual group coefficients, where the weight for a group equaled its share of the total number of observations in the census data.
3/ A weighted sum of the individual group coefficients, where the weight for a group equaled its share of gross farm production. The weights for groups 1-4 were, respectively, 0.433, 0.252, 0.192, and 0.123.

Table A-9 presents essential data for a test of such significant differences. The first three columns present differences between estimated production parameters for the three policy-affected groups and those for group 1. For each group, the last four columns show input means calculated directly from the county-level census data. Multiplying the difference between group 2 and group 1 estimated coefficients for a particular input by that input's mean value in group 2 yields a measure of the change in group 2's output (given input use), which is attributable to the difference between group 2's production parameter and that estimated for group 1. This operation is repeated for every input and results are summed and shown on the next to the last row of table A-9. The numbers in parentheses are the estimated standard error. 7/ (Corresponding statistics for groups 3 and 4 were obtained in a similar fashion.)

7/ When "productivity" for the j-th group is derived for the next to the last row, its variance corresponds to

$$\mathrm{Var}(1) = \frac{\sigma_1^2}{N_1} + \frac{\sigma_j^2}{N_j} + \Delta V \ (\mathrm{Var}\ \hat{\delta}_1)\ \Delta V',$$

and when calculated for the last line (continued)

These data indicate that the production function for each group affected by public policy is significantly different from that of group 1. Further, because all statistics are positive-valued, production functions resulting from public policies appear to be superior to the production function not affected by land reform and irrigation developments: that is, public policies have increased total factor productivity, or output per unit of total input, in Mexican agriculture.

The latter conclusion is double checked and reinterpreted by the statistics in the last row of table A-9. To obtain those data, differences in coefficients between the policy affected groups and the reference group, group 1, were multiplied by mean values of inputs in the reference group. Thus, these statistics show the change in output per unit of total input that would result in group 1 were irrigation or land reform policies imposed on it.

Results conflict with those of the next to the last row of the table: the estimate of productivity differences for groups 3 and 4 are not significant at usual levels of statistical confidence. Only if land reform were brought to bear on group 1 would that group's total factor productivity apparently increase.

How can these results be reconciled? How could the production function for group 3, for example, increase output per unit of input it is using, but not increase output per unit of input group 1 is using?

The answer is quite simple. The conflict, or ambiguity, in results reflects situations in which a group is favored with relatively low prices for inputs it would be expected to use--on technological grounds--most intensively. If a group is confronted with lower prices for inputs it would use least intensively, the ambiguity disappears.

At given, equal prices for inputs in all groups, differences in coefficients between group production functions indicate different intensities of input use. For example, if the coefficients on farm-supplied inputs were larger for group 1 than group 2, the intensity of use of these inputs would be considered highest in group 1. However, if the relative price of farm-supplied inputs were higher in group 1 than group 2, then production of any given level of output would be less expensive on group 1 farms were

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$$\mathrm{Var}(2) = \frac{\sigma_1^2}{N_1} + \frac{\sigma_j^2}{N_j} + \Delta V \;(\mathrm{Var}\;\hat{\delta}_j)\;\Delta V',$$

where subscripts identify the group, N is the number of observations in the group, σ^2 is the "explained" variance of output per farm, ΔV is a vector including mean differences in all input variables between the j-th group and group 1, and Var (δ) is the symmetric matrix of estimated variances and covariances of production function coefficients.

The basis for these expressions can be illustrated for the case of Var (1). Define the mean level of output in the j-th group as $\bar{Q}_j = \bar{V}_j\hat{\delta}_j$, $\bar{V}_j$ being a vector of the means of all "independent variables" (its first element equaling 1.0) and $\hat{\delta}_j$ being the vector of estimated coefficients (its first element being the estimated intercept). Correspondingly, define $\bar{\bar{Q}}_j = \bar{V}_j\hat{\delta}_1$. In this more concise notation, the productivity estimate,

$$\bar{Q}_j - \bar{\bar{Q}}_j = \bar{V}_j\hat{\delta}_j - \bar{V}_j\hat{\delta}_1 = \bar{V}_j\hat{\delta}_j - \bar{V}_1\hat{\delta}_1 + V\hat{\delta}_1.$$

Given the assumptions underlying the separate estimation of the production functions for these two groups (namely, "independence"), Var (1) follows directly.

Table A-9.--Calculated levels of productivity for each group relative to group 1, Mexico, 1960

Item	Differences in coefficients between group 1 and-- 1/			$\log_e$ means of inputs			
	Group 2	Group 3	Group 4	Group 1	Group 2	Group 3	Group 4
Constant	-0.004	-0.306	0.448	1.000	1.000	-.000	1.000
ρ	0.656	0.860	-0.809	0.391	0.241	0.287	0.161
Family labor	-0.233	0.083	-0.153	0.727	0.583	0.667	0.658
Hired labor	-0.084	-0.172	-0.196	-0.019	-3.734	-0.645	-3.365
Land	0.065	0.085	-0.183	2.997	1.612	3.329	1.865
Power and implements	0.012	-0.065	0.114	-0.027	-0.565	0.830	-1.061
ρ*Land	-0.228	-0.139	0.007	1.166	0.382	0.930	0.291
ρ*Livestock capital	0.441	-0.394	0.536	0.619	-0.132	0.426	-0.127
Group productivity:							
From equation 4 2/					0.240 (0.044)	0.124 (0.040)	0.304 (0.052)
From equation 4 1/ 3/					0.364 (0.051)	0.049 (0.040)	-0.005 (0.170)

1/ Based on regression 4 results.
2/ Equals the differences in coefficients for a group weighted by the mean of each input variable in that group. The numbers in parentheses are standard errors of the estimate.
3/ Equals the differences in coefficients for a group weighted by the mean of each input variable in group 1. The numbers in parentheses are standard errors of the estimate.

they supplied with group 2's production function, since there are savings on the use of the relatively expensive farm-supplied inputs. In other words, output per unit of total input in group 1 could be increased were it provided group 2's production function. For similar reasons, group 2's output would be higher with its own technology than it would be were group 1's imposed on it. On either test, group 2's production function would be superior.

This unambiguous case occurred in the data of table A-9 only in the comparison made between groups 1 and 2. Its significance is now understood in the following terms. Given that production function estimates for these two groups showed that the ejido sector outside SRH districts would use intensively most nonlabor inputs, the positive productivity differences for group 2 derived from both tests indicate that returns to nonlabor inputs are much higher than in group 1. Since high returns to nonlabor inputs are equivalent to low returns to labor inputs, this conclusion is in all respects consistent with a central hypothesis of this study: that nonalienation provisions of Mexican land reform have reduced the effective price of family labor.

The ambiguous productivity estimates for groups 3 and 4 indicate that these groups face lower prices for inputs, such as purchased inputs, that they use more intensively than group 1 does. For example, if unirrigated private farms face lower relative prices for farm-supplied inputs, and irrigated farms confront lower relative prices for

purchased inputs, no saving in production costs (or increases in productivity) would be anticipated by imposing irrigation technology on dryland private farms, given prices those farms face, even though production costs would fall and productivity would increase were all farms irrigated and provided lower relative prices for purchased inputs.

In summary, there are two principal implications of the production function estimates for cross-sectional measures of total factor productivity. First, public policies have altered the structure of Mexican agricultural production under at least one pattern of input employment: production functions of the policy-affected groups were statistically different from the production function of the reference group. Second, production functions of the policy-affected groups have increased output per unit of total input. Sources of this increase vary by policy: in the case of irrigation, they stem from low prices for purchased inputs used intensively in the SRH districts; in the case of land reform, they reflect the fact that unirrigated private sector units could benefit from ejido technology, as the price of labor confronting them is relatively high.

These conclusions, in turn, give rise to some answers to two important questions concerning Mexican public policies:

1. Should land reform be extended to the limits of the Agrarian Code? On the one hand, it has been shown that returns to family labor are low in the ejido sector, suggesting that on this limited view continued land reform would be uneconomic. On the other hand, it has been concluded that with a broader view of productivity--one which looks at all factors of production--land reform would increase output per unit of total input. Thus, extended land reform would yield mixed results: while increasing total factor productivity, it could reduce returns to the labor input. A choice between these outcomes would be difficult to make, since a sacrifice of labor returns would compromise the social spirit of Mexican land reform.

Fortunately, these outcomes are not the only ones: there are alternatives. The most viable would be to tax nonlabor inputs used by dryland private farms to bring their input ratio more into line with their apparent technological advantages. This could be coupled with an allocation of tax proceeds to ejido family members which would increase their willingness to leave agriculture.

2. Should irrigation developments continue? Certainly, on the total productivity criterion, irrigation pays. By imposing irrigation technology on dryland farms, relative prices of purchased inputs will fall for reasons discussed earlier. This change, together with the new technology of irrigation, was seen to increase output per unit of input. However, the present study does not show that these benefits are sufficiently large to offset social costs of irrigation investments.

Implications for Productivity Changes Through Time

That estimates based on group production functions assigned smaller weights to slow-growth inputs and larger weights to high-growth inputs than did the factor share weights, leads to an expectation that total input increases may have been understated, and total factor productivity overstated, by factor share estimates presented in chapter 4.

Data in table A-10, which combines tables 13 and 14 of chapter 4, largely support this expectation. Except for purchased inputs for 1940-53 and 1954-65 and labor for all time periods, an input's "contribution" was calculated by multiplying its "product share" average weight (taken from the last column of table A-8) by its compound rate of change over the corresponding time period (taken from table 13 of chapter 4). For labor, the estimated coefficient for a group was multiplied by that group's share in gross farm output and the input's growth rate in the group over the relevant time period. This was done for each group for a given labor class (for example, hired labor) and results were added to obtain the input's total contribution shown in table A-10. The special treatment of purchased inputs is discussed on pages 51-54 of this appendix. Thus, with

Table A-10.--Compound rates of change in inputs' contribution to gross farm output, based on 1960 factor shares and production function weights, Mexico, 1940-65

Input	Change in inputs' contribution to gross farm output					
	Based on 1960 factor share weights 1/			Based on production function weights 2/		
	1940-53	1954-65	1940-65	1940-53	1954-65	1940-65
	Percent					
Purchased inputs	0.5	0.7	0.6	3/0.7	3/1.6	3/1.2
Hired labor	0.7	0.1	0.4	1.7	0.3	1.0
Family labor	0.3	0.1	0.2	0.4	Nil.	0.2
All labor	1.0	0.2	0.6	2.3	0.2	1.3
Land	0.6	0.3	0.6	0.5	0.5	0.5
Livestock capital	0.4	0.4	0.5	0.5	0.5	0.7
Power and implements	0.5	0.2	0.3	0.8	0.3	0.6
Total input 4/	3.0	1.8	2.6	4.7	3.1	4.2
Total factor productivity	1.7	1.9	2.0	0.0	0.6	0.4
Total gross farm output	4.7	3.7	4.6	4.7	3.7	4.6

1/ From table 13.

2/ Except where noted explicitly, this is defined as the compound growth rate of an input times the "aggregate" input weight derived from regression 4 of each group production function shown in the last column of table A-8.

3/ The input weight used for 1940-53 assumed no irrigation. For 1954-65, it was assumed that this category of inputs would increase at no more than 4.0 percent a year on unirrigated land, given observed price movements. Since total use of purchased inputs increased 9.2 percent and SRH districts used 37.8 percent of the value of purchased inputs in 1960 (according to the county-level Census data), a 17.8-percent increase in purchased inputs inside SRH districts was implied. Weighting each of these rates by the appropriate product share aggregate input elasticities from regression 4 yielded the annual 1.6-percent "contribution;" that is, 0.074 (4.0) + 0.072 (17.8) = 1.6, where 0.074 = 0.102 (0.433) + 0.118 (0.252) and 0.072 = 0.287 (0.192) + 0.136 (0.123). For the whole period 1940-65 it was assumed that purchased inputs changed proportionately in all groups. As it turned out, the estimated contribution on this assumption is identically equal to that which would have resulted from assuming that this category increased 6.5 percent for 13 years and 17.8 percent for 12 years inside SRH and 6.5 percent for 13 years and 4.0 percent for 12 years outside SRH.

4/ No adjustment was made for changing group shares of aggregate output, for changing ratios of livestock output to gross farm production, or for the fact that the sum of the input elasticities deviated slightly from 1.0.

the above exceptions, contributions estimated from factor share weights are fully comparable to those estimated from production function weights.

Based on production functions weights, the annual change in total input is raised from 2.6 to 4.2 percent for 1940-65. Correspondingly, the difference between output and input changes, or total factor productivity, is reduced from 2.0 to 0.4 percent. By comparing individual input contributions for 1940-65 under the two estimating methods, the basic sources of this difference in estimated productivity are revealed.

The small, 0.2-percent annual contribution of family labor was the same for both methods of calculation, due largely to the input's slow rate of change. Also, the sum of contributions made by the land and livestock capital inputs (1.1 percent a year) were identical because the production function weights lowered the output contribution of the land input by the same amount (0.2 percent a year) as they raised the contribution of the livestock capital input. Hence, almost all of the additional change in output accounted for by the estimated production function weights can be attributed to the larger output contributions they assign to purchased inputs, power and implements, and hired labor.

These observations point to the basic explanation for the 2.0-percent annual growth in Mexican agricultural productivity during 1940-65. Much of the growth can be accounted for by the high productivity of purchased inputs and power and implements and the very rapid increase in their use; both factors, in turn, are related to the development of SRH irrigation districts. Most of the rest of the estimated increase in total factor productivity is the result of the way in which production function estimates allocated weights for the two principal labor categories, hired labor and family labor: smaller weights were assigned family labor by the production functions than by factor share estimates, principally because of the low productivity of the ejido sector's input, and larger weights were assigned the more rapidly growing hired farm labor category.

For the intraperiods 1940-53 and 1954-65, the method based on production function weights for calculating input contributions for purchased inputs was modified slightly to incorporate information not available for estimates derived from factor shares. In particular, it was assumed that--in the absence of public irrigation--the dryland use of purchased inputs would have expanded at about the rate of gross farm production outside SRH districts, as the relative price of purchased inputs was known to have been almost constant after 1953. From the crop production data presented later (see page 89), an upper bound estimate for that rate seemed to be represented by 4.0 percent a year. Given a 4.0-percent annual expansion in purchased inputs outside SRH districts, a lower bound estimate of the growth rate in purchased inputs inside SRH districts would be 17.8 percent a year. The latter figure was derived on the assumption that growth rates in the use of purchased inputs in the irrigated and unirrigated regions, weighted by the proportion of the value of all purchased inputs used by each in 1960, equaled the 9.2-percent yearly overall growth in their use. Thus, the 17.8-percent annual rate for irrigated regions and the 4.0-percent annual rate for unirrigated regions were multiplied separately by relevant production function weights for these areas to obtain the 1.6-percent contribution of purchased inputs to output for 1954-65. All other input contributions for that period shown in table A-8 were calculated in the way described above for 1940-65.

The sharp decline in relative prices of purchased inputs during 1940-53 explains too much of the increase in their use to argue that rates of change were as divergent between irrigated and unirrigated regions as in 1954-65. Further, SRH irrigation developments were just beginning to show progress in those early years. Thus, in deriving the 0.7-percent annual contribution of purchased inputs for 1940-53 from production function weights, another assumption was used: that technology of use of purchased inputs under irrigation was yet so unfamiliar to farmers that they used them "as if" they were operating without irrigation. While this assumption is more ad hoc than the one exploited for 1954-65, there is really less at stake, since it reduces the estimated contribution of purchased inputs by only 0.2 percent a year. The assumption underlying the

calculation of purchased inputs' contribution for 1954-65, on the other hand, increased that contribution by 0.4 percent a year. Again, all other input contributions for 1940-53 based on production function weights were estimated in the way defined above.

For 1940-53, the input index based on production function weights thus explains all the 4.7-percent annual increase in output. For 1954-65, however, and for the whole period 1940-65, small residual increases in output per unit of input do remain. The question is how these increases might be accounted for. Obvious possible answers are briefly discussed below.

1. No adjustments were made in these calculations of input contributions for changes in the scale of farms. 8/ However, available data suggest that scale effects in the private and ejido sectors were small and about offsetting in the aggregate. While the estimated scale parameter was much less than 1.0 in the ejido sector, the number of ejido units grew rather slowly on net after 1940 (1.3 percent a year). Numbers of large private farms increased more rapidly and consistently (2.2 percent a year), but the scale parameters for such units were just slightly in excess of 1.0 in the results of regression 4. 9/

2. Disaggregation of changes in the land input, similar to that effected in purchased inputs for the intraperiods, would explain none of the residual increase in productivity. For example, during 1954-65, cropland harvested inside SRH districts increased 2.1 percent a year. As of 1960, the SRH districts included 28.5 percent of the value of the land input. Given a 1.2-percent yearly expansion in all land, the

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8/ That is, the above calculations of input contributions are based on the observed rates of change of inputs, not the rates of change per farm. This introduces an "error" in the estimated change in total input which equals:

$$\Sigma_j \bar{P}_j (1.0 - S_j) \dot{F}_j,$$

where $\bar{P}_j$ is defined as the j-th group's share of aggregate output, S_j is the sum of the estimated coefficients in the production function for the j-th group, and F_j equals the rate of change in the number of farm units in the j-th group.

9/ Data on farm numbers by group are only available in the 1940, 1950, and 1960 Censuses of Mexican Agriculture. They show the following rates of change in farm units:

Time period	Large farms	Ejido units
1940-50	2.2	2.4
1950-60	2.2	0.2
1940-60	2.2	1.3

Since the rate of land redistribution was about constant during this 20-year period, one fact these data highlight is that ejido abandonment rates were highest in the second half of the period. Also, since the relevant weights from regression 4 to be applied against these rates are -0.034 and 0.066 for the private and ejido sectors, respectively, these data lead to the following estimates of "scale effects" on aggregate output.

Time period	"Scale" contributions
1940-50	0.1 percent
1950-60	-0.1 percent
1940-60	0.0 percent

implication is that land expansion outside SRH districts was "small" (0.8 percent a year). Applying appropriate production function weights (0.137 outside and 0.069 inside SRH districts) to these growth rates, a "disaggregate contribution" for land of 0.3 percent a year is obtained. This is identical to the figure shown in table A-10.

3. Three implicit assumptions were employed in deriving input contributions based both on the factor share and production function weights. One was that the shares of livestock output in aggregate output of the four production groups was constant through time. Another was that each group's share of gross farm output in Mexico showed no systematic change over the period. Finally, except in the cases of labor and purchased inputs, factors of production were assumed to grow at the same annual rate in each group. 10/ While there is no alternative to these assumptions, given available data, there is some indication that at least the latter assumption could account for a substantial part of the remaining growth in productivity indicated by table A-10 for 1954-65 and 1940-65. It was earlier shown that separation of growth rates of purchased inputs on irrigated and unirrigated lands made a difference in estimates of that input's contribution to the growth in gross farm output. The expectation would be that a similar form of disaggregation of calculations would adjust upwards the estimated rates of contribution of other high-growth inputs--in particular, power and implements. The data, however, preclude a more definitive test of this proposition.

Theoretical Basis for Differences in Production Function Coefficients

By postulating different production functions for groups of observations, equation (1) divides the total productivity effects of unmeasured, group-specific policy variables, denoted by P_j, into two parts. The first is input biased and manifests itself in between-group differences in estimated input elasticities. The second is input neutral: it redefines the effective units, or "productivity," of inputs and is reflected in differences between groups in estimated intercepts of the production functions.

When the production function for group 1 is taken as the basic reference relation on the assumption that it would apply to all farms and all regions in the absence of public polices, the production function for the j-th group can be rewritten formally to reveal both these effects.

$$(3) \quad \text{Log } Q_j = (\delta_{01} + \delta_{P_j} P^*_j) + \Sigma_1 (\delta_{i1} + \delta_{P_j} \frac{\partial \text{Log } P_j}{\partial \text{Log } V_{ij}}) \text{ Log } V_{ij} + u_j$$

where

$$(4) \quad \text{Log } P_j = P^*_j + \Sigma_1 \frac{\partial \text{Log } P_j}{\partial \text{Log } V_{ij}} \text{ Log } V_{ij} + e_j, \; j = 2, 3, 4,$$

$\delta_{P_j} = \partial \text{Log } Q_j / \partial \text{Log } P_j$ and e_j is a random independently distributed variable. From (3) it is seen that public policy is defined by systematic and random components. The production function for a policy-affected group is designed to capture both of its systematic components: the one that alters the structure of production through its relation to the use of other inputs and the one that changes the productivity of all inputs, given the change in structure, reflected in the intercept term. The sum of these two effects defines the total productivity impact of public policies; that is,

$$(5) \quad \Delta \text{Log } Q - \Sigma_1 \delta_{i1} \Delta \text{Log } V_i = \delta_{P_j} P^*_j + \Sigma_1 \delta_{P_j} \frac{\partial \text{Log } P_j}{\partial \text{Log } V_{ij}} \text{ Log } V_{ij},$$

where Δ denotes a mean difference between groups 1 and "j" and it is understood that all variables on the right are evaluated at their means.

10/ That these assumptions are distinct is demonstrated on pp. 79-88 of this appendix.

Equation (3) provides results that explain as much of the variation in aggregate output as the equation that includes the systematic policy variables explicitly. In addition, the policy effects cannot be misspecified, as might occur if the wrong "instrumental variable" were included in the production function to measure the essentially unmeasurable. Contrasting with these merits of the model are the liabilities of "free specification." If the P_j's are not specified, at least conceptually, differences in production functions cannot be explained. Results are left completely to the mercy of the data.

To preclude this, the present section will attempt to conceptualize the P_j's and indicate their expected influences on the signs of the between-group differences in input elasticities.

Needless to say, conceptualizing this form of input bias of public policies will not lead to a priori, null hypotheses about their total productivity impacts as measured by (5), since those depend as well on input-neutral effects and the actual levels of input use in the policy-affected groups. However, these latter sources of productivity are mainly empirical issues which are explored in the section on production function estimates (pp. 57-64).

Input-Bias of Land Reform

As a result of the Mexican Agrarian Code's nonalienation provisions, which prohibit sale or rental of ejido land, the major unmeasurable influences of land reform affect groups 2 and 4 (the ejido sector) and can be shown to operate primarily through the family labor input.

Define the annual cost, W_2, of a unit of family labor as the minimum annual wage required to keep such workers on the farm. For given labor quality and employment rates, this annual cost will generally overstate the supply price of ejidatarios. From it must be deducted an equivalent annual rent (subsidy) they perceive from the discounted future net returns on the parcels which they would have to forfeit--without compensation--were they to exit agriculture. This rent, R_4, will depend on marginal-value productivity of their land in the future, number of units owned, levels of use of non-land inputs, subjective rates of discount, and length of time horizons. If the unpaid family labor force consists of more than the ejidatarios, the subsidy is reduced to R_4/V_2, V_2 being the total number of family laborers, including the ejidatario, on the farm. The unitary cost of this labor thus becomes $W_2 - R_4/V_2$, which is clearly less than for labor in the private sector exhibiting similar skills and employment rates.

This subsidy to family labor can be equated with the ejido-specific unmeasurable variable which should appear in the production functions of that sector. Define "effective units" of family labor, V^*_2, as nominal (or measured) units times 1.0 minus the subsidy as a proportion of market labor costs; that is,

$$\text{Log } V^*_{2j} = \text{Log } V_{2j} + \text{Log } (1 - R_{4j}/V_{2j}\ W_{2j})$$

$$= \text{Log } V_{2j} + \text{Log } P_j,\ j = 2,\ 4.$$

For the case in which P_j is a positive fraction, the following observations can be made.

1. The direct effect of P_j on output is positive; that is,

$$\partial \text{Log } Q_j / \partial \text{Log } P_j = \delta_{P_j} \doteq > 0.$$

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2. The relation of P_j to family labor use is ambiguous on a priori grounds, although it would seem most likely that

$$\frac{\partial \text{Log } P_j}{\partial \text{Log } V_{2j}} = \frac{R_{4j}}{W_{2j}V_{2j}} \; \frac{(1 - \eta_{R_{4j}V_{2j}})}{(1 - R_{4j}/V_{2j}W_{2j})} < 0,$$

(where $\eta_{R_{4j}V_{2j}} = \partial \text{Log } R_{4j}/\partial \text{Log } V_{2j}$), since variation in family labor use is probably small relative to the (positively related) variation in R_4.

3. The relation between P_j and other inputs takes the form

$$\frac{\partial \text{Log } P_j}{\partial \text{Log } V_{ij}} = \{- \frac{\eta_{R_{4j}V_{ij}}}{(1 - R_{4j}/V_{2j}W_{2j})} \; (\frac{R_{4j}}{V_{2j}W_{2j}})\}$$

Changes in inputs which are complementary to land, including changes in the land input itself, would result in negative values for this elasticity, provided changes in current employment were in any sense "permanent," or likely to continue into the future. Since complementarity might be expected to dominate between land and other inputs--that is, more "other inputs" increase the marginal product of land--the above elasticities would be negatively valued in general.

These observations lead to an expectation that the input-biased effects of land reform will produce lower elasticities of production for most inputs in the ejido sector. In other words, the value of the "scale parameter" ($\sum_{i=1} \delta_{ij}$) should be less than in the private sector.

This is not inconsistent with at least two observations about the Mexican ejido. One is the fact that the ejido sector has remained a sector of small farms. Second, if land reform has led to decreasing returns to scale, the observation that the ejido's crop production response was sluggish (table 4) during the 1940-53 "Golden Era" of Mexican agriculture could be explained by the fact that entry is conditioned by the Government and the Government did not accelerate notably the rate of land redistribution during the 1940's and early 1950's. 11/

It is evident that P_j could be negative valued rather than positive valued; that is, the "effective return" to ejido family labor could be negative. In this case, the signs of the previously discussed elasticities would all be reversed. The conclusion regarding the scale parameter would, however, still hold.

There are no a priori grounds for either accepting or rejecting this outcome. However, a negative return to family labor in the Mexican ejido is not an entirely novel idea. Freebairn and Andrade (1), for example, concluded from their study of 2,518 ejidatarios in the Pacific Northwest "Valle del Yaqui" that returns to the ejidatario and his unpaid family workers were negative in 1957/58.

Input-Bias of Irrigation Developments

The most straightforward view of irrigation developments is that they have resulted in the adoption of a cost-saving technology--one characterized by more intensive use of purchased inputs, including power and implements, and less intensive use of most farm-supplied inputs.

11/ According to annual data in Memoria de Labores, Depto. de Asuntos Agrarios, land area distributed by presidential sexennium after 1940 was 5.3 million hectares (1940-46), 4.1 million (1946-52), 3.2 million (1952-58), and 8.2 million (1958-64).

Farmers in new SRH irrigation districts who initially were producing with dryland technology are confronted with the possibility of producing with an irrigation technology. They will ultimately make the change if it lowers their production costs. Those costs depend on relative prices of purchased and farm-supplied inputs, as well as the (required, "technical") intensities of use of the two input categories.

In case I of figure A-1, irrigation technology uses purchased inputs more intensively; that is, their share of total input is larger, which is indicated by tangency between the irrigation technology production isoquant and the preirrigation, solid price line at a higher ratio of purchased to farm-supplied inputs. 12/ If relative prices for purchased inputs were ultimately to fall in the irrigated regions (dotted price line), then the change to irrigation technology is assured since the dotted price line tangent to the dryland technology isoquant lies above, indicating higher production costs. Hence, the factor share of purchased inputs (farm-supplied inputs) for observations inside SRH districts should be larger (smaller) than for areas outside them, and this difference is indicative of the difference to be expected in the relevant "production elasticities" estimated for groups 3 and 4. 13/ The other three cases in the figure are similarly designed, but assumptions regarding factor intensities and relative input prices vary. None of them indicate an increase in the intensity of use of purchased inputs.

No part of the above argument translates neatly into a P_j-like variable, since it begins with an hypothesis that irrigation alters the form of the production function. There is, however, another important view of the impacts of irrigation policies that is amenable to the concept of a left-out, group-specific policy variable. It stems from the "big splash" hypothesis: namely, that public agencies most frequently attempt to improve input quality where the quantity of input already used is largest, since their own potential output, in terms of resources saved, is then largest per unit of time. This hypothesis is consistent with the observation that Mexican Government agencies do cultivate large farmers more carefully. Its implication is a positive relation between "quality" and quantity, even though all farms "waste" equal proportions of inputs and information (potentially) decreases wastage of every input unit by the same fraction.

To summarize, two effects of public irrigation developments have been identified. One derives from changes in relative input prices and technologies. The other derives from the quality-enhancing impacts of SRH developments on measured inputs. The first should be reflected in larger estimated coefficients on purchased inputs and smaller coefficients on farm-supplied inputs for the production functions of groups 3 and 4. It has been hypothesized that the second is positively related to output and to the use of purchased inputs. Therefore, it can be expected that the estimated production elasticities corresponding to purchased inputs for groups 3 and 4 will be larger than those for the reference group 1.

Yield Responses to Purchased Inputs Based on Mexican Experiment Station Data

At one stage of this study, an investigation was made of the experimental yield responses obtained from purchased inputs, as reported in published trials of the Rockefeller Mexican Program (RF) and the Mexican National Institute of Agricultural Research (INIA). In cooperation with the staff of INIA, the data format summarized by table A-11 was developed and all published experiments reported by the two research institutions during 1943-63 were tabulated. Information on rainfall and the use of other than purchased inputs was not included in the data format, as they had not been systematically reported by RF and INIA.

12/ Production functions are assumed to be linear and homogeneous.

13/ It is recognized that this argument is equivalent to that which assumed that the "true" production function describing the production process in the irrigated <u>and</u> unirrigated regions has an elasticity of substitution between purchased and farm-supplied inputs which exceeds 1.0.

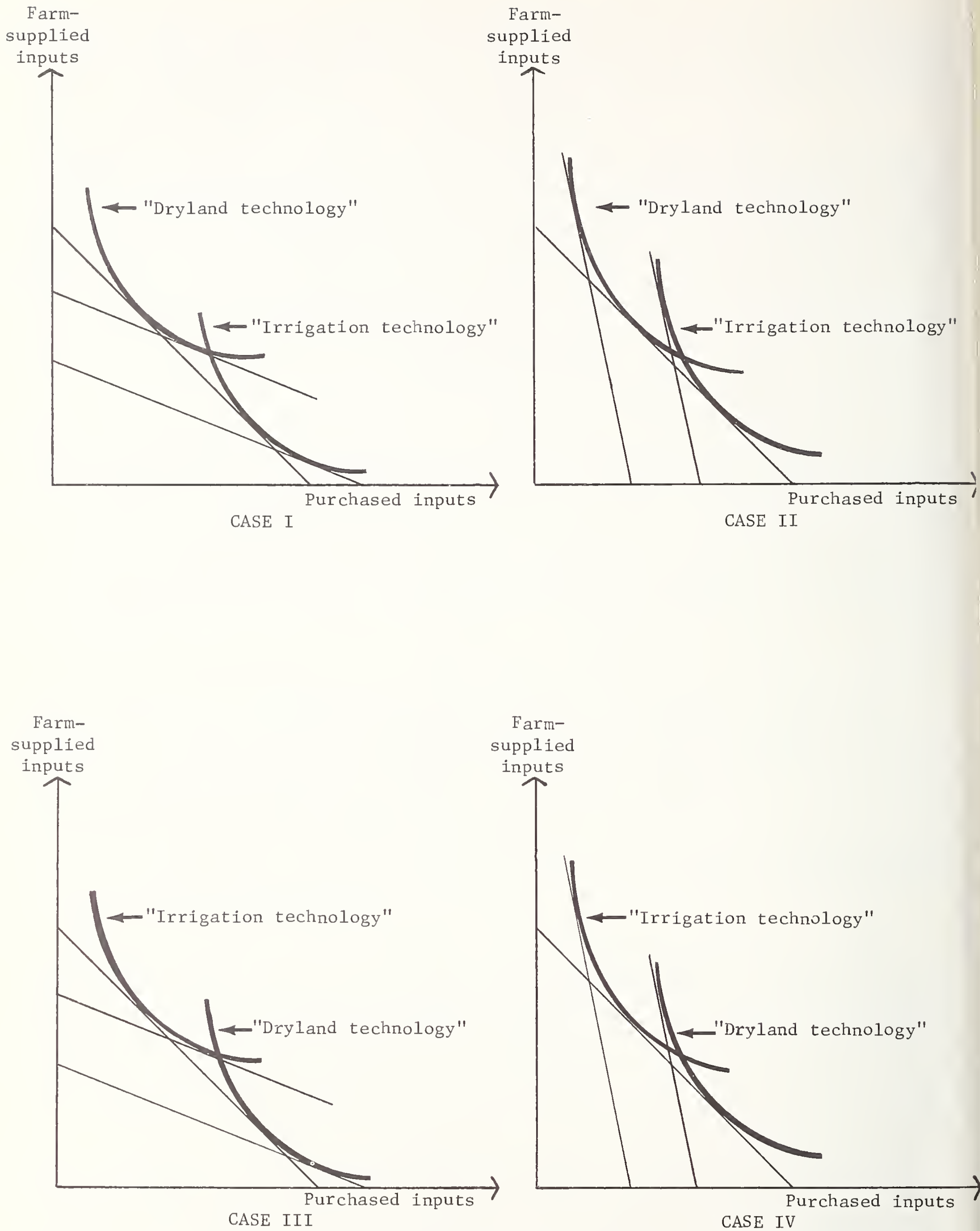

Figure A-1.--Illustrations of the change from "dryland" to "irrigation" technology

Table A-11.--Summary of data format used in experimental field trial analysis of purchased inputs, Mexico, 1943-63

Numerical order	Item
1.	Beginning date of the trial
2.	Location of the trial
3.	Type of seed or plant
4.	Seeding or planting densities
5.	Yield per hectare and date harvested
6.	Manner in which prior crop was removed from trial plot
7.	Number, volume, and dates of irrigation
8.	Type of fertilizers applied
9.	Quantity of fertilizers applied
10.	Content of N, P, and K
11.	Number of successive years fertilizers were applied on test plot
12.	Class of insecticides applied
13.	Quantity and type of active insecticide ingredients
14.	Number of insecticide applications and dates of application
15.	Class of herbicides applied
16.	Number of herbicide applications
17.	Quantity and class of herbicide active ingredients
18.	Number of manual weedings and dates
19.	Dates of herbicide applications

Although trials on all crops were tabulated, the data published on most crops, except wheat and corn, were incomplete. For example, in fertilizer experiments, levels of N, P, and K used were carefully reported, but the "constants" (for example, seeding and irrigation rates) were not. In seed experiments, much detail was provided on seed, but irrigation and fertilization levels were infrequently reported. This had two impacts on the analysis: first, only corn and wheat trials could be included; second, a zero-one dummy variable specification of independent variables had to be made.

The regressions fitted to these data measured the dependent variable as the trial yield (kilos per hectare) and the zero-one independent variable as the "adjusted" yields for the time period of the experiment; its location (17 primary locations were used for corn, 14 for wheat); and single, double, and full-treatment trials. Thus, the intercepts of these regressions can be interpreted as the average check-plot yield obtained using unimproved seeds, no irrigation, and no fertilizers in 1954-58 in the base location (Cd. Obregon, Sönora). Results are shown in table A-12 and can be summarized as follows:

1. Check-plot experimental yields on wheat corresponded closely to farm yields in 1954-58, but experimental corn yields were much higher than Mexico's average, reflecting the fact that in the case of corn, RF and INIA were using higher levels of inputs, other than purchased inputs, than farmers were.

Table A-12.--Experimental yield responses to three improved practices for corn and wheat, Mexico, 1944-63

Independent variable	Regression results		Implied 1954-58 yield levels 1/	
	Corn	Wheat	Corn	Wheat
			Bushels per acre	
1. Constant term	1786.5 (610.5)	1566.9 (100.7)	28.5	23.3
2. Seed variety	2/201.6 (349.3)	3/	28.5	23.3
3. Irrigation	1712.6 (615.2)	3/	55.8	23.3
4. Fertilization	944.1 (329.1)	703.2 (369.7)	43.5	33.8
5. Seeds*irrigation	2/489.2 (697.1)	3/	55.8	23.8
6. Seeds*fertilization	2/-39.7 (390.6)	2/214.3 (179.1)	43.5	33.8
7. Irrigation*fertilization	-933.2 (640.6)	690.0 (308.0)	70.8	44.0
8. Full treatment--"package"	2/745.5 (727.3)	3/	70.8	44.0
9. 1944-48	-2218.8 (198.5)	-1282.2 (310.4)		
10. 1949-53	818.3 (122.2)	-796.1 (202.5)		
11. 1959-63	-207.9 (100.7)	531.1 (46.3)		
R^2	0.116	0.173		
Number of observations	3,903	2,348		

1/ By way of reference, Mexican yields on corn and wheat averaged 13.2 and 19.4 bushels, respectively, during 1954-58. Mexican farm prices received averaged US$1.25 for corn and US$1.79 for wheat.
2/ Not significant at $t_{0.05}$.
3/ Variable was eliminated by the regression program because it exceeded preset levels of tolerance.

2. The simple zero-one, criolla-improved specification on the seed variable was so inefficient as to preclude identifying yield differences due to improved seeds--apparently because experiments on both corn and wheat were generally designed to test yields and product and disease-resistance qualities of different varieties of already improved, or preselected, seeds. Thus, the true criolla was infrequently employed as a check variety.

3. One implication of the above is that some of the effects of (improvement in) the check variety seed may have been captured by the time and location variables.

4. If agronomic complementarity in the use of purchased inputs were important, estimated coefficients for double and full-treatment trials would be expected to be large, positive, and statistically significant. In the case of corn, it is apparent that yield effects are additive. In the case of wheat, however, some "interactions" are indicated.

Rationale of the Aggregate Cobb-Douglas Composition Model

The Mexican Agricultural Census makes no allocation of input use to particular farm products, product categories, or subsectors of agriculture. For example, information is available for construction of an aggregate labor input, but no indication is given of the proportion of the aggregate used in particular outputs or even output categories.

Persons conducting productivity studies on other countries and confronted with similarly designed data have generally adopted the "aggregate production function" as their working model. 14/ Intuition would suggest that production coefficients estimated from such a relation are some combination of the production coefficients associated with each product. The implication is that effective total input could be different between groups of observations simply because of differences in the mix of final outputs and the distribution of inputs between those outputs.

This problem cannot be handled like the "left-out" policy variables, since what is left out is in this instance unknown. In other words, the form of the "true" production function that incorporates the effects of variation in product mix for each group is undefined.

To work towards a satisfactory definition, an explicit production model was constructed that incorporated only assumptions and information acceptable in light of the data at hand. Specifically, it was assumed that there were two outputs (q_1, q_2) and two inputs ($V_1 = V_{11} + V_{21}$ and $V_2 = V_{12} + V_{22}$), with information available only on the aggregates, V_1 and V_2. Group subscripts are omitted for simplicity. Further, to avoid ambiguity about the index of aggregate output 15/ ($Q = p_1q_1 + p_2q_2$), product prices (p_1, p_2) were assumed constant and prices of corresponding inputs were assumed constant and equal between products. Finally, it was assumed that product functions were of the constant returns, Cobb-Douglas form and that equilibrium conditions were satisfied in each product. The model implied by these assumptions is summarized in the following system of eight equations.

14/ There are a few notable exceptions. Zvi Griliches, "Estimates of the Aggregate Agricultural Production Function from Cross-Sectional Data," Jour. Farm Econ., XLV, No. 2 (May 1963), 419-28; Yair Mundlak, "Specification and Estimation of Multiproduct Production Functions," Jour. Farm Econ., XLV, No. 2 (May 1963), 433-43. Also, Yair Mundlak, "Transcendental Multiproduct Production Functions," International Econ., Rev. V, No. 3 (Sept. 1964), 273-84.

15/ The source of this ambiguity arises from the fact that, if product prices are not assumed constant, the output index should be adjusted along the transformation curve for the two outputs. But its shape is unknown. This point is discussed by Mundlak, ibid.

Definitions

q_1, q_2 : Outputs of products 1 and 2.

p_1, p_2 : Prices of products 1 and 2.

V_{1i}, V_{2i}: Quantities of the i-th input used in products 1 and 2, i=1,2.

W_i : Price of the i-th input, assumed to be the same in each product.

V_i : $V_{1i} + V_{2i}$

s_{1i}, s_{2i}: Proportions of i-th input used in products 1 and 2.

R : V_2/V_1

R_1, R_2 : Ratios of the use of input 2 to input 1 in products 1 and 2.

α_{1i}, α_{2i}: Elasticity of product 1's output with respect to the i-th input.

Model

(1) $q_1 = V_{11} R_1^{\alpha_{12}}$

(2) $q_2 = V_{21} R_2^{\alpha_{22}}$

(3) $R_1 = \frac{\alpha_{12}}{\alpha_{11}} \frac{W_1}{W_2}$

(4) $R_2 = \frac{\alpha_{22}}{\alpha_{21}} \frac{W_1}{W_2}$

(5) $R = s_{11}R_1 + (1-s_{11})R_2$

(6) $V_1 = V_{11} + V_{21}$

(7) $p_1 q_1 = W_1 V_{11} + W_2 V_{12}$

(8) $p_2 q_2 = W_1 V_{21} + W_2 V_{22}$

Given values of the production function parameters, factor prices, V_1, and R, table A-13 provides values of the unknown variables and parameters. In the table, Q, ρ, δ_1, and δ_2 are defined respectively as the value of aggregate output, product 2's share of aggregate output, and the "aggregate" factor shares of the two inputs.

The economic conclusions which emerge are:

1. The share of an aggregate input in aggregate output is simply a weighted average of the shares the input represents of each output, where weights correspond to each output's share in aggregate output. This can be demonstrated by multiplying the identity, $V_i = V_{1i} + V_{2i}$, by the market price $(\tilde{W}_i)$ of the input such that

$$\tilde{W}_i V_i = \tilde{W}_i V_{1i} + \tilde{W}_i V_{2i}, \text{ or}$$

$$(9) \qquad \frac{\tilde{W}_i V_i}{Q} = \frac{\tilde{W}_i V_{1i}}{p_1 q_1} (p_1 q_1/Q) + \frac{\tilde{W}_i V_{2i}}{p_2 q_2} (p_2 q_2/Q).$$

If fixed factor shares are assumed, then

$$\alpha_{i1} = \frac{\tilde{W}_i V_{i1}}{p_1 q_1} \text{ and } \alpha_{i2} = \frac{\tilde{W}_i V_{i2}}{p_2 q_2} .$$

Since $\delta_i = \frac{\tilde{W}_i V_i}{Q}$, $\rho = \frac{p_2 q_2}{Q}$, and $(1-\rho) = \frac{p_1 q_1}{Q}$ equation (9) becomes

$$\delta_i = \alpha_{i1} (1-\rho) + \alpha_{i2} \rho$$

$$(10) \qquad \delta_i = [\alpha_{i1} + (\alpha_{i2} - \alpha_{i1}) \rho]$$

2. When relevant prices are fixed and equilibrium prevails, factor ratios are fixed for each product. Rates of change in the use of an input between products will be different, however, and the shares of the aggregate input going to each product will be variable. Only in the trivial cases where either aggregate inputs change in fixed proportion to each other or the underlying product functions exhibit identical (fixed) factor shares for corresponding inputs can it be said that factor shares in the aggregate are constant.

For the more general case, the i-th input elasticity parameter, δ_i, of the aggregate production function of equation (1) p. 50 should thus be redefined from (10) as

$$(11) \qquad \tilde{\delta}_i = [\tilde{\alpha}_{1i} + (\tilde{\alpha}_{2i} - \tilde{\alpha}_{1i}) \rho],$$

where $\tilde{\alpha}_{1i}$ is the i-th input's share of total input in product 1, $\tilde{\alpha}_{2i}$ is similarly defined in terms of product 2, and ρ is product 2's share of aggregate output. Using this definition of the δ's, the Cobb-Douglas relation (1) then becomes the "true" form of the aggregate production functions, when two products are produced under full equilibrium.

A major question arises over "identification" of the model--in brief, why do ratios of aggregate inputs differ between observations? In the single-product case, where relevant prices and input parameters are the same for all producers, but "planned" levels of output differ between them, there is essentially only one reason that input ratios could be different between observations: namely, if farmers are imperfect profit-maximizers. 16/ In the corresponding multiproduct case, there are potentially two reasons: different farmers could choose to produce different "planned" ratios of outputs and/or they could allocate inputs in each output inefficiently, given planned output ratios. The first reason needs no elaboration, since it follows directly from (9), (10) and (11) provided $(\tilde{\alpha}_{2i} - \tilde{\alpha}_{1i})$ is not equal for all "i"; that is

$$(12) \qquad V_i = [\tilde{\alpha}_{1i} + (\tilde{\alpha}_{2i} - \tilde{\alpha}_{1i}) \rho^*] \frac{Q^*}{\tilde{W}_i}$$

asterisks denoting "planned" values of variables.

16/ See Marc Nerlove, Estimation and Identification of Cobb-Douglas Production Functions (Chicago: Rand McNally and Co., 1965), ch. II, pp. 18-38.

Table A-13.--Examples of the composition model for a study of Mexican agricultural productivity, 1940-65

Item	Situation			
	1	2	3	4
Given:				
α_{11}	0.50	0.50	0.50	0.50
α_{12}	0.50	0.50	0.50	0.50
α_{21}	0.33	0.33	0.33	0.33
α_{22}	0.67	0.67	0.67	0.67
W_1	4	4	4	4
W_2	2	2	2	2
V_1	100	120	86	200
V_2	300	300	301	600
R	3.0	2.5	3.5	3.0
Derived:				
V_{11}	50	90	21.5	100
V_{12}	100	180	43	200
V_{21}	50	30	64.5	100
V_{22}	200	120	258	400
q_1	70.7	127.1	30.4	141.4
q_2	125.8	75.6	162.2	251.6
p_1q_1	400	720	172	800
p_2q_2	600	360	774	1200
Q	1000	1080	946	2000
s_{11}	0.50	0.75	0.25	0.50
s_{12}	0.33	0.60	0.14	0.33
s_{21}	0.50	0.25	0.75	0.50
s_{22}	0.67	0.40	0.86	0.67
ρ	0.60	0.33	0.82	0.60
δ_1	0.40	0.44	0.36	0.40
δ_2	0.60	0.56	0.64	0.60

The second presents a potentially fruitful method of identification, but in practice would be untenable because "planned" ratios of outputs could not be observed if there were input misallocation between products and, hence, the estimated elasticity of aggregate output with respect to aggregate input would be biased by reason of a divergence between measured product shares, ρ, and ρ^*.

In general terms, given available data, this problem cannot be circumvented. In less general terms, however, there is a solution which permits a particular type of "disequilibrium." Simply assume that producers in a production group mismeasure the (constant) market price of the i-th input, but allocate its use between products efficiently on the basis of that mismeasured price. Corresponding to the derivation in (9) and (10) above,

$$W_iV_i = W_iV_{1i} + W_iV_{2i}, \text{ or}$$

$$\frac{W_iV_i}{Q} = \frac{W_iV_{1i}}{p_1q_1}(p_1q_1/Q) + \frac{W_iV_{2i}}{p_2q_2}(p_2q_2/Q), \text{ and}$$

$$\delta_i = [\alpha_{1i} + (\alpha_{2i} - \alpha_{1i})\rho^*], \tag{13}$$

tildes being omitted to denote a divergence between market values and "true" values of parameters. This specification uses equilibrium assumptions for its derivation, but still permits "disequilibrium." Variations in the desired ratios of outputs are both the source of the differences in aggregate input ratios and the "identification" of an aggregate production function, like equation (1), with input elasticities defined by (13). 17/

Justification for the use of the model in the Mexican case goes beyond its logic and empirical exigencies. If input misallocation between products, instead of "planned" output ratios, were the primary reason for the appearance of different aggregate input ratios, production functions should be able to be identified for given values of ρ. At one point in this study, an experiment was performed to look at this possibility.

Observations of the county-level Census data were divided into 30 subsets. Within a subset, the ratio of livestock output to gross farm production, defined here and elsewhere in this analysis as "ρ," fell into a preselected range for all observations. The interval selected for one subset of observations did not overlap that of any other subset. Output and input variables were defined as earlier described, and dummy variables were introduced to adjust intercepts and input coefficients for tenure class (ejido-private) and location (inside-outside SRH districts). The production functions fitted were otherwise of the Cobb-Douglas form.

In the results (presented in the following tables), high R^2's and high standard errors on estimated coefficients were evidenced. A majority of the input elasticities were statistically insignificant at usual levels of the t-statistic. This evidence, although not conclusive, did seem to indicate that input misallocations between products were a less important "identifier" of different aggregate input ratios in the case of the Mexican Census data than were the ratios of outputs farmers "planned" to produce. Thus, the "equilibrium" multiproduct model of production appears to offer a useful means of identifying and estimating the four individual group production functions.

17/ Even in this case, the "true" ρ might not be observed unless the equation errors in the individual product functions were identically distributed. To claim that they are identically distributed is to assume really that the two products are grown under the same roof.

Table A-14.--Aggregate production functions from 1960 county-level Mexican Agricultural Census data, adjusted for "policies" and given ρ first 15 intervals

Reg. no.	Mean of ρ	Std. dev. of ρ	No. of obser-vations	Independent variable for-- Private sector, outside SRH: Labor	Power	Live-stock input	Pur-chased inputs	Land	Total ejido sector 1/: Labor	Power	Live-stock input	Vari-able exp.	Land	Both sectors, inside SRH: Labor	Power	Live-stock input	Pur-chased inputs	Land	R^2
1.	0.007	0.003	71	0.266*	0.032*	0.106*	0.262	0.547	0.166*	0.032*	-0.214*	0.016*	0.155*	0.128*	-0.343*	0.469	0.067*	-0.423	0.914
				(0.230)	(0.150)	(0.123)	(0.098)	(0.141)	(0.403)	(0.173)	(0.150)	(0.117)	(0.156)	(0.408)	(0.217)	(0.142)	(0.116)	(0.157)	
2.	0.018	0.004	102	0.357	0.107*	0.307	0.175	0.467	-0.506	-0.183*	-0.101*	0.171*	0.133*	0.131*	0.182*	0.031*	-0.171*	-0.210	0.918
				(0.152)	(0.090)	(0.106)	(0.070)	(0.073)	(0.211)	(0.114)	(0.126)	(0.104)	(0.091)	(0.318)	(0.220)	(0.131)	(0.188)	(0.098)	
3.	0.033	0.004	99	0.381	-0.115*	0.391	0.130*	0.451	-0.481	0.099*	0.075*	0.079*	0.004*	-0.382*	0.149*	0.350	-0.135*	-0.153*	0.892
				(0.175)	(0.090)	(0.119)	(0.082)	(0.115)	(0.245)	(0.141)	(0.156)	(0.118)	(0.129)	(0.247)	(0.154)	(0.185)	(0.159)	(0.129)	
4.	0.047	0.004	113	0.230*	-0.025*	0.307	0.352	0.386	-0.290*	0.171*	0.215*	-0.276	-0.249	-0.144*	0.145*	-0.171*	-0.246	0.058*	0.852
				(0.202)	(0.102)	(0.136)	(0.102)	(0.101)	(0.237)	(0.139)	(0.197)	(0.120)	(0.130)	(0.325)	(0.166)	(0.237)	(0.133)	(0.123)	
5.	0.063	0.004	94	-0.037*	0.028*	-0.026*	0.433	0.426	00.098*	0.019*	1.100	-0.504	-0.248*	-0.393*	-0.058*	-0.405*	0.466*	-0.183*	0.880
				(0.135)	(0.097)	(0.175)	(0.081)	(0.135)	(0.225)	(0.127)	(0.196)	(0.123)	(0.164)	(0.526)	(0.266)	(0.443)	(0.376)	(0.202)	
6.	0.079	0.005	99	0.624	-0.166*	0.825	0.043*	0.010*	-0.413*	0.351	-0.406	-0.303	0.399	-0.239*	-0.244*	-0.448*	0.349*	0.221*	0.882
				(0.238)	(0.123)	(0.138)	(0.089)	(0.106)	(0.270)	(0.153)	(0.198)	(0.137)	(0.142)	(0.344)	(0.285)	(0.341)	(0.239)	(0.162)	
7.	0.092	0.004	98	0.342	-0.029*	0.396	0.101*	0.327	-0.219*	0.041*	0.035*	0.165	-0.007	-0.390*	-0.015*	0.142*	0.175*	-0.016*	0.912
				(0.118)	(0.070)	(0.090)	(0.066)	(0.077)	(0.162)	(0.106)	(0.107)	(0.097)	(0.120)	(0.235)	(0.167)	(0.211)	(0.161)	(0.142)	
8.	0.108	0.004	116	0.053*	0.133*	0.394	0.136*	0.369	-0.125*	-0.056*	0.001*	0.020*	0.102*	-0.076*	-0.208*	0.029*	0.168*	-0.022*	0.861
				(0.117)	(0.098)	(0.097)	(0.112)	(0.087)	(0.131)	(0.117)	(0.125)	(0.128)	(0.134)	(0.212)	(0.156)	(0.146)	(0.219)	(0.156)	
9.	0.123	0.004	112	0.096*	0.290	0.872	-0.289	0.102*	0.128	-0.186*	-0.030*	0.341	-0.055*	-0.168*	-0.012*	-0.131*	0.170*	0.210*	0.891
				(0.198)	(0.086)	(0.101)	(0.086)	(0.085)	(0.225)	(0.114)	(0.148)	(0.117)	(0.113)	(0.245)	(0.151)	(0.240)	(0.110)	(0.153)	
10.	0.140	0.006	116	-0.148*	-0.097*	0.971	-0.099*	0.212	0.269*	0.006*	-0.364	0.251	0.132*	-0.229*	0.059*	-0.000*	0.177*	-0.280	0.897
				(0.188)	(0.143)	(0.139)	(0.111)	(0.103)	(0.188)	(0.154)	(0.154)	(0.127)	(0.124)	(0.202)	(0.223)	(0.249)	(0.193)	(0.149)	
11.	0.159	0.006	120	-0.325	0.314	0.451	0.017	0.222*	0.398	-0.236	0.084*	0.098*	0.013*	-0.037*	0.003*	-0.257*	0.102*	0.201*	0.851
				(0.160)	(0.078)	(0.090)	(0.076)	(0.075)	(0.197)	(0.130)	(0.169)	(0.108)	(0.134)	(0.218)	(0.227)	(0.186)	(0.204)	(0.132)	
12.	0.180	0.006	111	0.462	-0.182	0.086*	0.454	0.290	-0.458	0.298	0.447	-0.178*	-0.135*	-0.024*	0.263*	-0.164*	-0.195*	0.107*	0.923
				(0.186)	(0.069)	(0.067)	(0.099)	(0.094)	(0.191)	(0.103)	(0.097)	(0.116)	(0.122)	(0.172)	(0.215)	(0.185)	(0.149)	(0.230)	
13.	0.199	0.005	104	0.406	0.161	0.609	0.073*	0.080*	-0.564	-0.204	0.093*	0.191	0.047*	0.172*	0.028*	-0.027*	0.005*	0.174*	0.932
				(0.155)	(0.070)	(0.082)	(0.046)	(0.083)	(0.207)	(0.097)	(0.148)	(0.091)	(0.125)	(0.185)	(0.132)	(0.184)	(0.133)	(0.177)	
14.	0.221	0.006	124	0.232*	0.085*	0.473	-0.004*	0.361	-0.178*	-0.011*	-0.104*	0.117*	-0.091*	0.024*	0.129*	-0.222*	0.210*	-0.212*	0.901
				(0.142)	(0.091)	(0.086)	(0.059)	(0.091)	(0.152)	(0.112)	(0.113)	(0.085)	(0.118)	(0.228)	(0.211)	(0.222)	(0.219)	(0.243)	
15.	0.240	0.006	110	0.129*	0.060*	0.497	0.234	0.180	-0.230*	0.288	-0.470	0.042*	0.253	0.884	0.384	0.793	-0.733	-0.441	0.877
				(0.129)	(0.094)	(0.087)	(0.105)	(0.077)	(0.159)	(0.143)	(0.100)	(0.135)	(0.131)	(0.275)	(0.188)	(0.159)	(0.205)	(0.141)	

*Not statistically significant at the 5-percent level of "t."
1/ Irrigated and nonirrigated.

Table A-15.--Aggregate production functions from 1960 county-level Mexican Agricultural Census data, adjusted for "policies" and given ρ, last 15 intervals

Reg. no.	Mean of ρ	Std. dev. of ρ	No. of obser- vations	Independent variable for-- Private sector, outside SRH: Labor	Power	Live- stock input	Pur- chased inputs	Land	Total ejido sector 1/: Labor	Power	Live- stock input	Vari- able exp.	Land	Both sectors, inside SRH: Labor	Power	Live- stock input	Pur- chased: inputs	Land	R^2
16.	0.260	0.006	101	0.019*	0.018*	0.662	0.273	0.046*	0.006*	0.076*	-0.158*	-0.197*	0.204*	-0.052*	0.349*	-0.467*	-0.212*	0.116*	0.880
				(0.199)	(0.097)	(0.120)	(0.107)	(0.101)	(0.218)	(0.134)	(0.162)	(0.131)	(0.130)	(0.306)	(0.351)	(0.310)	(0.264)	(0.202)	
17.	0.281	0.006	87	-0.017*	0.186	0.545	0.011*	0.207	0.008*	-0.056*	0.096*	0.065*	0.137*	0.131*	0.106*	0.129*	-0.129*	-0.088*	0.906
				(0.150)	(0.071)	(0.101)	(0.060)	(0.077)	(0.174)	(0.116)	(0.175)	(0.076)	(0.136)	(0.641)	(0.278)	(0.396)	(0.270)	(0.305)	
18.	0.305	0.008	115	0.153*	0.241	0.265	0.135	0.135	0.027*	-0.181*	0.264	0.029*	0.076*	-0.035*	-0.041*	0.111*	0.075*	-0.101*	0.870
				(0.156)	(0.086)	(0.098)	(0.055)	(0.073)	(0.185)	(0.121)	(0.156)	(0.084)	(0.108)	(0.278)	(0.197)	(0.239)	(0.278)	(0.198)	
19.	0.338	0.011	145	0.303	0.133	0.427	0.090*	0.230	-0.203*	0.170	-0.030*	-0.008*	-0.051	0.030*	-0.032*	0.204	-0.177*	-0.120*	0.913
				(0.121)	(0.056)	(0.070)	(0.062)	(0.059)	(0.127)	(0.090)	(0.096)	(0.077)	(0.081)	(0.119)	(0.105)	(0.111)	(0.117)	(0.086)	
20.	0.379	0.011	139	0.124*	0.278	0.402	0.119	0.159)	0.405	-0.195	0.589	-0.009*	-0.382	-0.001*	-0.306	-0.211*	0.201*	0.216*	0.924
				(0.102)	(0.064)	(0.062)	(0.052)	(0.055)	(0.141)	(0.110)	(0.111)	(0.090)	(0.110)	(0.309)	(0.171)	(0.170)	(0.134)	(0.173)	
21.	0.419	0.012	118	0.169*	0.108*	0.705	-0.003	0.133	-0.041*	-0.002*	-0.179*	0.249	-0.007	0.863*	-0.707	-0.141*	0.660	0.344*	0.878
				(0.194)	(0.073)	(0.106)	(0.047)	(0.076)	(0.225)	(0.126)	(0.165)	(0.094)	(0.122)	(0.584)	(0.276)	(0.175)	(0.246)	(0.263)	
22.	0.464	0.015	114	0.318	0.226	0.485	0.016*	0.132	-0.592*	-0.183*	0.202*	0.083*	-0.014*	1.018*	-0.276*	-0.132*	0.406*	-0.157*	0.840
				(0.153)	(0.062)	(0.086)	(0.061)	(0.061)	(0.433)	(0.218)	(0.235)	(0.194)	(0.151)	(1.056)	(0.365)	(0.551)	(0.534)	(0.329)	
23.	0.509	0.011	87	0.333	0.315	0.591	-0.082*	0.139	-0.006*	-0.501	-0.021*	0.212*	0.188*	0.414	0.717	1.243*	0.001*	0.712*	0.999
				(0.154)	(0.092)	(0.085)	(0.115)	(0.176)	(0.237)	(0.225)	(0.187)	(0.188)	(0.160)	(0.660)	(0.859)	(1.488)	(0.387)	(0.511)	
24.	0.554	0.015	105	0.284	0.048*	0.875	0.036*	-0.010*	-0.391*	0.204	0.053*	0.010*	-0.163*	0.383*	0.771	-0.797	0.007*	-0.225*	0.938
				(0.131)	(0.056)	(0.069)	(0.059)	(0.061)	(0.234)	(0.095)	(0.123)	(0.122)	(0.148)	(0.367)	(0.284)	(0.234)	(0.242)	(0.248)	
25.	0.608	0.016	102	0.525	0.013*	0.454	0.255	0.100*	-0.580	0.020*	0.086*	-0.123*	-0.246	0.783*	0.324*	0.556*	-0.744	-0.082*	0.886
				(0.152)	(0.080)	(0.087)	(0.090)	(0.079)	(0.263)	(0.234)	(0.239)	(0.191)	(0.142)	(0.691)	(0.288)	(0.340)	(0.366)	(0.254)	
26.	0.666	0.018	83	0.209*	0.234	0.651	0.014*	0.040*	-0.281*	-0.185*	-0.025*	0.168*	0.123*	-1.192*	-1.025*	-0.245	1.152	-0.533*	0.912
				(0.153)	(0.072)	(0.089)	(0.063)	(0.062)	(0.211)	(0.151)	(0.149)	(0.120)	(0.170)	(2.863)	(0.954)	(0.138)	(0.493)	(0.600)	
27.	0.733	0.019	78	0.151*	0.133*	0.589	0.140*	-0.034*	-0.801	-0.025*	-0.207*	0.124*	0.275*	0.264*	-0.054*	-0.385*	-0.285*	-0.064*	0.869
				(0.160)	(0.088)	(0.087)	(0.087)	(0.077)	(0.377)	(0.129)	(0.319)	(0.280)	(0.329)	(0.640)	(0.390)	(0.353)	(0.339)	(0.281)	
28.	0.797	0.022	86	0.294	0.124	0.674	0.092*	-0.046	-0.459	-0.063*	0.289*	-0.080*	0.043*	-0.300*	N.C.	-0.067*	-0.004*	0.117*	0.895
				(0.151)	(0.054)	(0.069)	(0.055)	(0.066)	(0.255)	(0.338)	(0.536)	(0.291)	(0.162)	(0.969)		(0.639)	(0.514)	(0.339)	
29.	0.877	0.021	67	0.339	0.039*	0.652	0.167	0.071*	-1.391	0.030*	-0.233*	-0.146*	0.393*	N.C.	-0.429*	0.761*	-0.397*	-0.426*	0.935
				(0.160)	(0.090)	(0.082)	(0.068)	(0.051)	(0.444)	(0.134)	(0.212)	(0.146)	(0.251)		(0.311)	(0.499)	(0.537)	(0.259)	
30.	0.955	0.023	58	0.062*	0.046*	0.851	0.009*	0.002	N.C.	-24.924*	0.020*	2.466*	12.308*	N.C.	N.C.	N.C.	N.C.	7.469*	0.938
				(0.168)	(0.058)	(0.066)	(0.063)	(0.040)		(22.082)	(0.876)	(2.080)	(10.403)					(7.189)	

*Not statistically significant at the 5 percent level of "t."
N.C. = not calculated by regression program.
1/ Irrigated and nonirrigated.

Productivity Differences Between Policy-Affected Groups

In figure A-2 a situation is described in which group 1 uses farm-supplied inputs more intensively than group 2 at given, equal relative input prices (denoted by the slope of the line "ab") for the two groups.

Assume that for both groups the ratio of use of the two inputs falls on the line "ocd," with group 2 using inputs at point "c" and group 1, at point "d," to which there corresponds a high relative price for the farm-supplied inputs group 1 would use most intensively (shown by the slope of the dotted straight line).

This is the unambiguous case discussed on pp. 64-68 of this appendix. For if group 1's production function is imposed on group 2 at "c" (indicated by the dotted isoquant 1' lying below 1), output per unit of input for group 2 will fall; that is, the next to the last line of table A-10 would include positive values. Similarly, if group 2's production function is imposed on group 1 at the point "d," group 1's productivity would increase (the last line of table A-10 would include positive values). Thus, on either grounds, group 2's production function is the superior one.

Figure A-3 illustrates the ambiguous case. Here group 1 is producing at "a" and group 2 at "b." Note that group 1's relative price for the farm-supplied inputs it would use intensively is low and that group 2's relative price for the purchased inputs it would use intensively is low. If group 1's production function were imposed on group 2 at point "b," group 2 productivity would fall (the next to the last line of table A-10 would include positive values). If group 2's production function were imposed, however, on group 1, group 1's productivity would fall (the last line of table A-10 would include negative values).

Optimal Aggregation of the Group Production Functions

Conceptually related to the discussion in the section on the rationale of the aggregate Cobb-Douglas composition model (pp. 79-85) is the issue of how the group production functions might be "optimally" aggregated in those instances in which reliable time series are unavailable for particular inputs by group. In essence, the question is: What is the form of the "true" production function that is, in some sense, an aggregate of the four groups?

The equilibrium, multiproduct model developed on pages 79-85 is of no help since--as separate estimation implies--the four group production functions are assumed to be independent relations. By this it is meant that there is no systematic attempt by a "larger" decision unit that encompasses operations of the four groups (for example, Government), to achieve equality of marginal value products of an input between production groups. Indeed, were such an attempt made and the assumptions of the "equilibrium" multiproduct model satisfied, it might be expected that factor ratios of a group, like those of a single product, would be fixed and that production functions estimated separately for each could not be identified.

The model of independence in production can, however, be profitably viewed as the theoretical "other side" of the multiproduct production coin. Input use is the result of independent decisions made in each group, and literally anything can happen. Input ratios in all groups can be variable and--most unlike the equilibrium case--a group's share of total output need not be systematically related to the amount of total input employed by the four groups, or thus to the amount of the input it employs.

Following this lead, aggregate output of the four groups will be defined as

$$Q = \sum_j p_j q_j ,$$

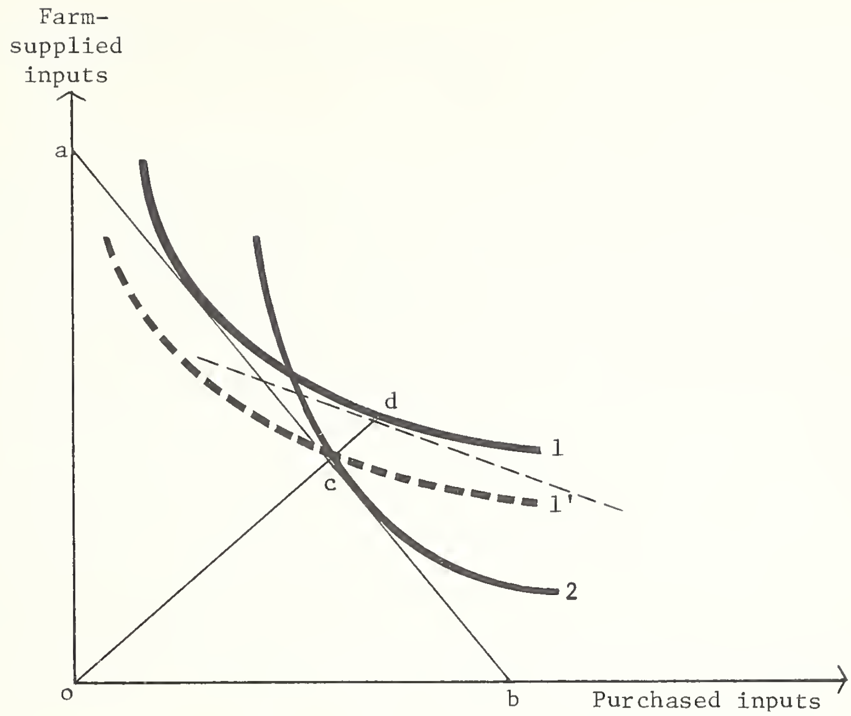

Figure A-2.--The unambiguous case of productivity differences

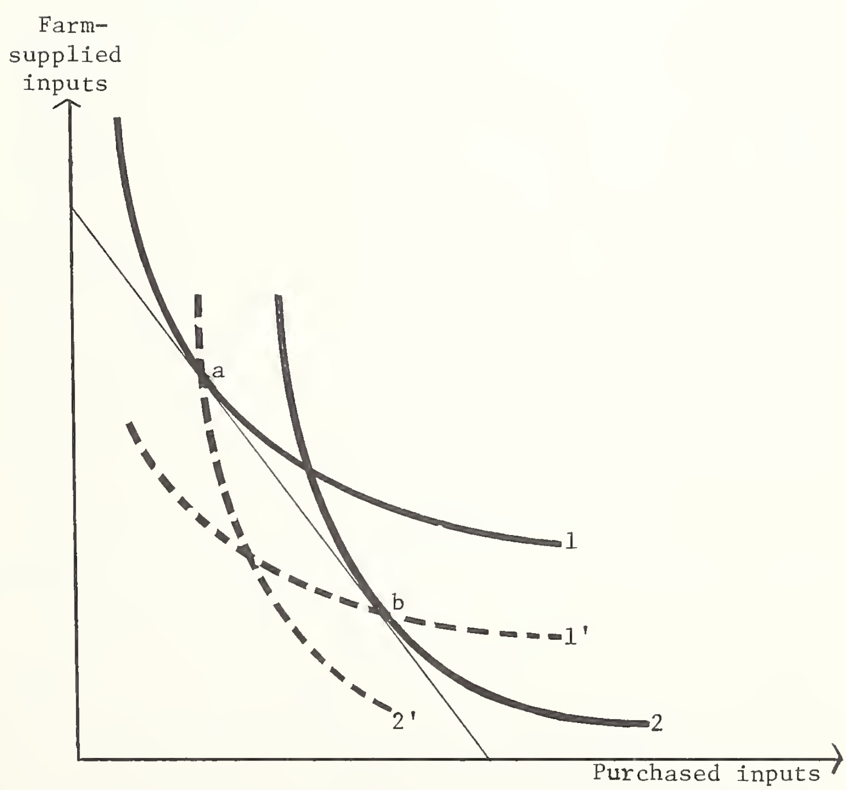

Figure A-3.--The ambiguous case of productivity differences

p_j and q_j being appropriate indices of (fixed) prices and quantities produced in each group. The total differential of this equation per unit of time will be written as

$$(1) \quad \dot{Q} = \Sigma_j \sum_{i=1} \bar{P}_j(\delta_{ij}\dot{V}_{ij}),$$

(where $\bar{P}_j$ is the j-th group's share of Q), since V_{ij} is independent of V_{ik} $(k \neq j)$, V_{ij} is independent of V_{nj} $(n \neq i)$, $\bar{P}_j$ is independent of input employment, and group intercepts are defined to be "input-neutral." (Because the elasticity parameters are technically dependent on input ratios, the above statement should be viewed as a "convenient" approximation when time series on ρ_j are unavailable, as is the case in this study.)

On the basis of (1) it is seen that there are two circumstances in which computation of the index of aggregate input would not require separate data on input use by group.

1. The elasticity parameters for an input were equal in every policy-affected group to those in group 1. Assuming that the observed change in the aggregate value of the input, in fact, equalled in this case $\Sigma_j \bar{P}_j \dot{V}_{ij}$, the input's contribution to the change in aggregate output would be calculated simply as $\delta_{i1} \dot{V}_i$.

2. The use of an input changes at the same rate in every group. In this case the appropriate measure of the i-th input's contribution to the change in aggregate output would be $\Sigma_j \bar{P}_j \delta_{ij} \dot{V}_i$.

APPENDIX B.--TIME SERIES AND DIRECT FACTOR SHARE ESTIMATES

Time Series on Production, Consumption, and Land Use: Sources and Methods

Crop Production and Land Area Harvested

Crop production data, valued at 1960 farm gate prices reported in the 1960 Mexican Agricultural Census, were estimated from two basic sources: the Mexican Agricultural Censuses of 1940, 1950, and 1960, and annual data of the Direccion General de Economia Agricola, Mexican Secretariate of Agriculture (DGEA/SAG).

In the estimating procedure, the Census data were taken as benchmarks for adjustments of the annual DGEA/SAG data. Prior to adjustment, the latter series was modified to take into account differences between the crop year and crop definitions of the two series.

Interpolation of the Census data with the DGEA/SAG data was carried out individually on 37 principal crops--for both land area harvested and production. The parameters of the equations used in interpolation were defined for each 10-year period by solving

$$C_{ti} = a_{ti}\ (t) + \mathrm{DGEA/SAG}_{ti}$$

$$C_{(t+10)i} = a_{ti} + b_{i(t+10)} + \mathrm{DGEA/SAG}_{(t+10)i}$$

where "t" equals the first year of the 10-year period interpolated and "i" refers to one of 37 crops. DGEA/SAG is the relevant annual estimate of that agency; "C" is the corresponding Census report.

The crops included were the following:

Alfalfa	Garlic	Pineapple
Bananas	Green chile	Potatoes
Barley	Green tomatoes	Rice
Beans	Henequen	Sesame
Broad beans	Jicama	Strawberries
Castor	Lentils	Sugarcane
Coconut	Melon	Sweetpotatoes
Coffee	Oats	Tobacco
Corn	Onions	Tomatoes
Cotton	Oranges	Vetch
Dry chile	Peanuts	Watermelon
Flaxseed	Peas	Wheat
Garbanzo		

The effect of this adjustment procedure was to reduce the production growth rate and increase the crop yield growth rate as compared with those rates based on the unadjusted DGEA/SAG series.

Meat Production

All data, except those on Federally Inspected Slaughter Plants (TIF) and farm slaughter, were estimated by Finis Welch under contract with USDA and are based on annual data reported by the Direccion General de Estadistica, SIC, Mexico. Welch made a small adjustment in the data of SIC on municipal slaughter to account for a reduction in the coverage of slaughter houses during 1942-52.

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TIF slaughter has been reported annually by the Foreign Agricultural Service, USDA, since TIF operations were inaugurated in 1950. Some slaughter was undertaken by plants which later became TIF plants during 1947-49. These data were included in the TIF series. This slaughter occurred under a special arrangement of the Joint U.S.-Mexican Foot and Mouth Disease Eradication Program, and is only reported in a file copy of a document prepared in January 1952, by the Production Marketing Administration, USDA.

Farm slaughter was estimated on the basis of Mexican Agricultural Census data that indicated a ratio of sales to production of 0.70 in 1940 and 0.95 in 1950 and 1960. The ratio for 1940 was brought up to 0.95 for 1950 by arithmetic interpolation and held at that level for 1950-65 in estimating the farm "production" series presented earlier in table 4.

The meat production series presented in table 4 thus differ from Welch's series as a result of including both TIF and onfarm slaughter of livestock.

All livestock production data were aggregated using 1960 carcass-basis prices of livestock at the first-identified point of sale--the municipal slaughter houses.

Dairy Production

For dairy production, national milk consumption was estimated first, by fitting a log regression in which the dependent variable was the consumption of fresh milk per capita in the Federal District less per capita incomes multiplied by the income elasticity of demand for fresh milk estimated in the ERS projections of supply and demand for agricultural products in Mexico (46). The independent variables were the retail prices of fresh milk, eggs, beef, cheese, corn, and beans. The parameters obtained from this regression were then applied to comparable income and price data relating to the entire Republic. The resulting series was used to interpolate the fresh milk consumption implied by the production reports of the Agricultural Census and the trade data of the Direccion General de Estadistica, SIC.

From the resulting series on fresh milk consumption, together with data on fresh imports and exports and the percentage of domestic production diverted for industrialization, fresh milk production was derived directly.

Exports and imports were estimated from data of the Direccion General de Estadistica, SIC, and include fresh milk; condensed, evaporated, and dry milk; and butter and cheese products. Nonfresh products were converted to fresh milk equivalent, using 2.3, 2.14, 7.6, 21.1, and 10 kilos, respectively, of fresh milk for each kilo of condensed, evaporated, and dry milk, and butter and cheese.

The percentage of fresh milk diverted for industrialization was based on annual estimates of the Foreign Agricultural Service, USDA, and was adjusted to the decennial data of the Mexican Agricultural Census in a way outlined above for crops.

Consumption Data

In all cases except that of dairy products explained above, consumption series for agricultural commodities were derived in this report as the sum of corresponding production and net imports, or equivalent imports minus exports. Quantity data on agricultural trade were weighted by the same 1960 farm gate prices used for weighting production for purposes of aggregating exported and imported items.

Time Series on Production, Yield, and Area Harvested for Principal Crops

Tables B-1 through B-3 provide some detail on 1940-62 trends in nine principal crops. Data sources and estimating methods are discussed in appendix A on pp. 50-57.

Table B-1.--Indexes of production for nine principal crops in Mexico, 1940-62

Year	Corn	Cotton	Coffee	Beans	Wheat	Henequen	Sugar-cane	Tomatoes	Rice
	1960=100								
1940	52	16	13	24	37	41	35	13	58
1941	49	16	16	19	39	41	39	13	59
1942	58	18	20	31	38	40	46	23	58
1943	62	25	23	36	41	47	53	31	56
1944	55	28	27	34	31	53	59	38	58
1945	64	27	31	40	32	50	53	42	52
1946	63	23	34	38	31	46	55	48	58
1947	68	20	38	37	31	49	60	40	65
1948	72	21	41	48	38	53	70	45	63
1949	77	27	45	51	43	53	79	56	73
1950	79	50	49	56	46	49	83	69	83
1951	81	65	54	58	52	51	73	79	82
1952	88	72	59	56	49	53	74	82	77
1953	84	66	64	55	47	56	75	82	63
1954	85	70	71	53	57	59	78	91	65
1955	94	101	75	71	68	67	83	94	68
1956	92	132	81	84	74	71	79	94	85
1957	95	107	85	80	104	76	62	95	95
1958	88	139	91	77	108	82	83	84	96
1959	98	139	98	90	104	89	92	91	99
1960	100	100	100	100	100	100	100	100	100
1961	98	123	108	92	95	105	101	109	128
1962	107	118	113	118	110	108	103	140	129
	Percent								
Compound rate of of change:									
1940-53	4.3	11.5	11.6	7.5	2.5	2.1	5.9	13.8	2.6
1954-62	1.9	17.3	5.9	7.4	7.1	7.7	4.3	3.7	8.3
1940-62	3.3	10.9	9.2	3.8	6.1	4.2	3.9	8.8	3.5
Share in the value of production of 37 crops:									
1960	32.7	15.3	8.2	6.9	8.2	3.7	4.9	1.6	1.4

Table B-2.--Indexes of output per unit of land harvested, nine principal crops in Mexico, 1940-62

Year	Corn	Cotton	Coffee	Beans	Wheat	Henequen	Sugar-cane	Tomatoes	Rice
	1960=100								
1940	74	60	29	60	57	74	90	47	101
1941	67	61	36	47	59	71	97	47	83
1942	78	50	42	65	58	64	101	56	98
1943	79	59	49	63	62	65	110	66	82
1944	79	57	56	67	54	69	115	76	88
1945	86	57	65	71	55	63	105	70	80
1946	83	51	72	67	59	55	108	74	111
1947	90	51	80	64	63	58	114	65	123
1948	91	51	88	82	66	61	127	71	108
1949	94	53	95	78	72	60	130	72	113
1950	94	69	100	71	72	54	123	99	92
1951	91	65	98	68	69	56	116	92	95
1952	94	62	103	70	66	58	113	93	93
1953	92	64	105	75	69	60	107	88	107
1954	92	71	102	87	70	63	106	94	91
1955	99	82	107	84	69	71	104	94	104
1956	97	94	105	94	80	75	99	94	120
1957	101	93	107	75	99	79	96	92	105
1958	96	98	97	101	106	84	104	88	105
1959	96	102	100	93	113	91	103	92	104
1960	100	100	100	100	100	100	100	100	100
1961	112	102	102	107	105	102	93	106	111
1962	112	113	104	100	126	105	96	145	110
	Percent								
Compound rates of change:									
1940-53	2.3	0.8	9.8	2.1	1.8	-1.8	1.6	16.8	1.1
1954-62	1.9	4.5	-0.4	-4.0	7.0	6.4	-1.1	3.7	1.0
1940-62	1.7	3.5	4.8	2.7	3.4	1.9	-0.3	3.5	0.8

Table B-3.--Indexes of land area harvested, nine principal crops in Mexico, 1940-62

Year	Corn	Cotton	Coffee	Beans	Wheat	Henequen	Sugar-cane	Tomatoes	Rice
	1960=100								
1940	70	26	46	41	64	55	39	25	58
1941	74	35	45	41	67	58	40	28	71
1942	75	35	47	47	66	62	45	40	59
1943	79	42	47	57	66	71	48	48	68
1944	70	49	48	51	58	76	51	50	66
1945	75	47	48	56	58	80	51	60	64
1946	76	44	47	57	53	83	51	65	52
1947	75	40	47	57	49	84	53	61	53
1948	79	42	47	58	57	86	56	64	59
1949	82	52	74	66	60	88	60	77	65
1950	84	72	49	79	64	91	68	70	90
1951	88	100	55	85	75	91	62	85	86
1952	88	117	57	80	74	92	66	89	83
1953	85	104	62	74	68	93	70	93	59
1954	92	98	70	73	81	93	73	98	71
1955	95	123	71	84	91	94	80	99	66
1956	94	140	77	89	92	95	80	100	71
1957	94	116	79	106	105	96	65	103	90
1958	91	121	94	76	101	97	80	96	92
1959	103	136	98	97	92	98	89	99	96
1960	100	100	100	100	100	100	100	100	100
1961	88	120	106	86	90	103	108	102	115
1962	96	105	108	118	88	104	108	96	118
	Percent								
Compound rates of change:									
1940-53	1.6	10.5	6.9	5.3	0.6	4.0	4.3	9.1	1.5
1954-62	0.3	-0.5	6.1	3.6	0.6	1.4	5.4	-0.1	7.4
1940-62	1.6	7.5	4.3	4.0	2.7	2.4	4.2	6.0	2.7
Share of acreage harvested in 37 crops:									
1960	59.4	6.6	3.3	6.5	7.4	2.0	2.6	0.4	0.8

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Tables B-4 through B-6 summarize additional data on four crop aggregate series. They demonstrate that highest growth in crop production has come from export and "introduced" crops, but that most recent growth has been attributable primarily to the latter. Table B-7 shows wholesale and retail price indices for major agricultural products.

The notion of high growth being associated with "introduced" crops has gained some currency among Rockefeller Foundation technicians in Mexico. Norman Borlaug is one of its primary proponents. The hypothesis is that changes in traditional farming practices are effected most easily by introducing new crops which are not indigenous to a country. This hypothesis deserves cross-country examination.

Farm Prices Paid and Received Series 18/

Irrigation Water Prices

Table B-8 summarizes the basic income (water charges collected), volume, and price series for irrigation water distributed by the Mexican Secretariate of Water Resources (SRH) during 1948-65. Accounting data on each SRH district were aggregated to the national level in a way which attempted to preserve correspondence in each year between "income" and "volume." The assistance of Ing. Luis de la Loma, Chief, Direccion General de Estadistica y Estudios Economicos, SRH, in obtaining the information is gratefully acknowledged.

Several words of caution about these data are necessary. First, Mexico's irrigation districts, totaling over 100, have not typically had fixed boundaries. Districts have been named, renamed, stretched, and shrunken in size with very little official note being taken of these changes. This constant flux made extremely difficult a consistent allocation of volume and income data to each district. Second, income divided by volume cannot give an unqualified price estimate because of the lag which naturally exists in collecting water charges. Finally, one element of total income from water could not be accounted for: the "compensation charge," a per hectare surcharge levied on certain districts and based on a proration of a project's capitalized investment outlay over a maximum of 25 years.

The price data for 1940-42 were obtained from accounting information of the Banco Nacional de Credito Agricola, which served as interim manager of the irrigation districts during the early 1940's, when their operations were being transferred from the old "Comision" to SRH.

Comparable data on water prices could not be located for 1943-47. Data in table B-8 are thus based on a simple, arithmetic interpolation of the 1942 and 1948 price statistics.

Fertilizer Prices

The index of fertilizer prices was based on implicit prices for N and P estimated from regressions of GUANOMEX fertilizer prices in each year on their content of N, P, and K (table B-9). Before 1954, only about 10 types of fertilizers were sold by GUANOMEX and its predecessors. Thus, one regression was run for 1939-53 and prices of N, P, and K, and the intercept term of the regression were permitted to vary with time (see coefficients on Nt, Pt, Kt, and t in table B-9).

From these results, a "production price" was calculated (table B-10). Quantities of N and P produced in 1960 were used as weights (table B-11) for the estimated prices of these nutrients. The standard errors of estimated prices from the 1939-53 regression were unacceptably high on all but the 1939 price of nitrogen and "Pt." Thus, only their

18/ Insecticide prices are discussed in chapter 4 of this report.

Table B-4.--Indexes of production, four crop aggregates, Mexico, 1940-62

Year	Subsistence crops 1/	Export crops 2/	Introduced crops 3/	Indigenous crops 4/
	1960=100			
1940	47	21	32	49
1941	45	21	35	47
1942	54	23	38	55
1943	58	29	44	59
1944	52	33	35	54
1945	60	34	38	63
1946	59	33	37	63
1947	63	33	38	67
1948	67	35	46	70
1949	73	40	48	76
1950	75	53	53	78
1951	77	62	57	78
1952	78	66	56	82
1953	74	65	54	77
1954	82	70	60	84
1955	91	88	67	93
1956	90	105	72	91
1957	87	95	97	88
1958	86	103	103	88
1959	97	117	102	98
1960	100	100	100	100
1961	96	115	95	97
1962	109	117	108	108
	Percent			
Compound rates of change:				
1940-53	4.2	9.1	4.2	4.2
1954-62	2.7	4.9	6.8	2.4
1940-62	3.6	8.6	6.0	3.4

1/ Beans, corn, dry chile.
2/ Bananas, coffee, cotton, garbanzo, garlic, henequen, red tomatoes.
3/ Alfalfa, oats, sesame, wheat.
4/ Corn, pineapple, potatoes, tobacco, and red tomatoes.

Table B-5.--Indexes of output per unit of land harvested for crop aggregates, Mexico, 1940-62

Year	Subsistence crops 1/	Export crops 2/	Introduced crops 3/	Indigenous crops 4/
	1960=100			
1940	70	49	60	71
1941	63	48	61	64
1942	75	46	63	74
1943	75	53	67	76
1944	76	55	63	78
1945	83	57	64	85
1946	80	55	68	83
1947	85	57	74	89
1948	88	60	76	90
1949	91	62	78	93
1950	90	71	76	93
1951	87	69	73	90
1952	90	68	72	93
1953	89	71	74	91
1954	91	77	72	91
1955	112	82	75	115
1956	96	93	80	96
1957	91	93	96	94
1958	98	95	103	97
1959	109	100	108	111
1960	100	100	100	100
1961	114	103	104	115
1962	112	112	118	113
	Percent			
Compound rates of change:				
1940-53	2.4	3.3	1.9	2.6
1954-62	1.9	4.0	5.9	1.9
1940-62	2.1	4.0	2.7	2.0

1/ Beans, corn, dry chile.
2/ Bananas, coffee, cotton, garbanzo, garlic, henequen, red tomatoes.
3/ Alfalfa, oats, sesame, wheat.
4/ Corn, pineapple, potatoes, tobacco, and red tomatoes.

Table B-6.--Indexes of land area harvested, four crop aggregates, Mexico, 1940-62

Year	Subsistence crops 1/	Export crops 2/	Introduced crops 3/	Indigenous crops 4/
	1960=100			
1940	67	43	53	70
1941	71	43	58	73
1942	72	49	60	75
1943	77	55	65	78
1944	68	60	56	70
1945	73	60	58	74
1946	74	60	54	76
1947	73	58	51	75
1948	77	59	60	78
1949	80	65	62	82
1950	83	75	69	84
1951	89	89	79	89
1952	88	97	78	88
1953	84	92	73	84
1954	90	91	82	92
1955	81	107	89	80
1956	94	113	90	94
1957	95	102	101	94
1958	88	109	101	91
1959	89	117	95	88
1960	100	100	100	100
1961	84	112	91	84
1962	98	105	92	96
	Percent			
Compound rates of change:				
1940-53	1.9	5.7	2.2	1.6
1954-62	0.8	1.0	1.1	0.6
1940-62	1.6	4.6	2.7	1.3

1/ Beans, corn, dry chile.
2/ Bananas, coffee, cotton, garbanzo, garlic, henequen, red tomatoes.
3/ Alfalfa, oats, sesame, wheat.
4/ Corn, pineapple, potatoes, tobacco, and red tomatoes.

Table B-7.--Price indexes at wholesale and retail levels of distribution, Mexico, 1940-65

Year	Wholesale 1/ (1960=100) Animal products	Fruit	Vegetables	Cereals	All non-processed foods 2/	All consumption articles 3/	General 4/	Retail general 5/
1940	11.2	14.0	14.9	18.3	16.3	17.4	17.4	9.2
1941	12.1	14.3	15.2	19.5	17.3	18.4	18.5	9.9
1942	13.9	17.7	19.3	19.9	19.0	20.5	20.4	12.1
1943	18.5	25.9	20.7	26.3	24.0	25.6	24.7	15.9
1944	27.7	49.1	32.9	37.3	32.8	33.0	30.3	22.9
1945	34.5	38.5	34.4	41.5	37.9	37.9	33.7	26.7
1946	38.5	46.2	37.9	49.5	44.0	44.1	38.8	34.6
1947	37.9	49.3	35.2	54.2	45.4	45.7	41.0	37.4
1948	37.5	50.0	42.8	49.5	45.9	46.9	44.0	37.4
1949	37.2	57.4	46.1	46.9	46.6	48.8	48.2	41.4
1950	41.0	47.2	41.7	56.2	49.2	52.5	52.7	43.9
1951	49.5	71.1	58.7	80.0	63.5	65.3	65.4	54.0
1952	55.8	67.4	71.6	81.8	68.2	68.7	67.8	65.3
1953	54.7	71.6	58.9	76.9	66.3	66.9	66.5	62.7
1954	57.5	84.0	61.7	78.1	70.0	71.5	72.7	68.7
1955	71.3	99.2	86.2	81.3	79.9	81.7	82.6	79.0
1956	78.1	95.0	76.7	89.4	84.4	86.4	86.5	81.9
1957	78.4	92.3	83.1	105.0	89.0	90.5	90.2	85.5
1958	83.8	109.8	97.2	109.5	95.2	95.6	94.2	92.2
1959	95.1	99.7	101.5	92.0	95.6	96.3	95.3	97.0
1960	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1961	100.0	100.4	73.9	103.3	100.1	101.0	100.9	100.7
1962	100.7	116.5	81.6	106.9	103.1	104.1	102.8	101.7
1963	99.5	106.0	77.9	110.1	102.5	103.9	103.3	101.8
1964	103.9	120.7	100.4	117.3	108.6	108.7	107.7	106.5
1965	108.5	114.2	90.1	119.7	110.4	111.1	109.7	110.0

1/ From Banco de Mexico, S.A., for Mexico City.
2/ Based on preceding four categories.
3/ Processed and non-processed consumption articles.
4/ 216 items.
5/ From Direccion de Estadistica, S.I.C., for Mexico City.

Table B-8.--Volume, income, and price data relating to SRH irrigation districts, Mexico, 1940-65

Year	Water distributed	Income collected	"Price"
	Mil. cu. meters	1,000 pesos	Pesos per mil. cu. meters
1940			611
1941			856
1942			1,068
1943			1,135
1944			1,202
1945			1,269
1946			1,336
1947			1,403
1948	6,714	9,404	1,401
1949	7,058	10,474	1,484
1950	6,582	12,720	1,933
1951	6,064	16,830	2,775
1952	7,201	19,999	2,777
1953	8,904	21,668	2,433
1954	9,691	33,086	3,414
1955	12,326	38,669	3,137
1956	13,296	46,244	3,478
1957	15,124	42,552	2,813
1958	13,932	51,610	3,704
1959	15,429	53,019	3,436
1960	17,273	88,113	5,101
1961	17,691	97,932	5,536
1962	17,184	116,195	6,762
1963	15,067	101,841	6,759
1964	15,269	124,818	8,174
1965	16,007	123,124	7,692

Source: 1940-42, Banco Nacional de Credito Agricola, 1943-47, based on arithmetic trend. 1948-65, Secretaria de Recursos Hidraulicos, Direccion de los Distritos de Riego.

Table B-9.--Regression results used in fertilizer price index, Mexico, average 1939-53 and annual 1954-65

Year	Independent variable 1/ N	P	K	Intercept	R^2	Number of observations
1939-53	1.792 (1.191)	0.950 (.745)	-0.378 (.544)	-133.57	0.766	58
	Nt	Pt	Kt	t		
	-0.057 (0.117)	-0.104 (0.075)	0.105 (0.053)	43.331 (19.132)		
1954	3.929 (0.623)	2.102 (0.574)	1.841 (0.304)	-128.45	0.631	32
1955	2.681 (0.634)	0.439 (0.533)	0.997 (0.255)	169.98	0.885	29
1956	3.909 (0.295)	2.123 (0.252)	1.477 (0.185)	-26.46	0.878	29
1957	3.987 (0.320)	2.202 (0.274)	1.539 (0.201)	-62.03	0.863	29
1958	5.005 (0.531)	3.750 (0.546)	2.142 (0.271)	-302.88	0.762	33
1959	5.090 (0.551	3.101 (0.378)	1.984 (0.262)	-195.29	0.748	35
1960	4.609 (0.519)	3.043 (0.379)	1.666 (0.258)	-133.73	0.722	37
1961	4.617 (0.508)	3.315 (0.499)	1.733 (0.243)	-170.37	0.764	31
1962	3.621 (0.781)	2.299 (0.441)	1.116 (0.305)	104.52	0.580	26
1963	3.561 (0.800)	2.271 (0.451)	1.279 (0.312)	114.38	0.549	26
1964	2.584 (0.495)	1.616 (0.377)	1.977 (0.956)	247.95	0.705	18
1965	2.537 (0.483)	1.589 (0.368)	1.918 (0.932)	263.14	0.707	18

1/ First number in each year is the estimated regression coefficient; the second is its standard error.

Table B-10.--Price indexes for fertilizers, Mexico, 1940-65

(1960=100)

Year	Underlying price indexes				Farm price
	Production price	Production subsidy	Import price	Implicit import tax	
1940	54	99	75	72	54
1941	54	101	67	81	54
1942	53	103	131	42	55
1943	52	105	83	67	55
1944	52	107	65	86	56
1945	51	109	59	95	56
1946	50	112	79	71	56
1947	50	114	86	66	56
1948	49	116	85	67	57
1949	48	119	156	37	57
1950	48	121	126	46	58
1951	47	124	110	53	58
1952	46	126	145	40	58
1953	45	129	142	41	59
1954	82	99	118	69	81
1955	49	112	154	36	55
1956	82	103	102	82	84
1957	84	101	43	199	85
1958	111	97	99	109	108
1959	109	99	100	107	109
1960	100	100	100	100	100
1961	78	97	81	123	99
1962	78	107	89	94	83
1963	77	107	88	93	82
1964	55	114	66	97	63
1965	55	115	76	83	63

coefficients entered the price index for 1940-53. The price of phosphate during this period was taken equal to its implicit 1954 price plus 0.104 (1954 - t), "t" being the pre-1954 year in question.

In several years, the intercepts of the price regressions were negative valued, suggesting that GUANOMEX and its predecessors may have been subsidizing fertilizer consumption. The second column of table B-10 expresses this apparent subsidy (estimated intercept of the price regressions) as a proportion of the "pure" production price and coverts the resulting series to an index with a 1960 base.

The third column of table B-10 presents an index of the value of all fertilizers imported divided by the sum of their N, P, and K content times a "quality index" defined in year "t" as

$$I_t = \Sigma_i (N_{it}/N_{io}) p_{io} / \Sigma_i p_{io},$$

where N_{it} is the percentage the i-th nutrient represented of all imported nutrients in year "t", and p_{io} is the implicit 1960 "production price" of the same nutrient. The import value data, upon which the import price is based, do not include import taxes.

The farm price index was estimated on the assumption that production subsidies and import taxes were manipulated through time by the Mexican Government in such ways as to make the price of nutrients imported approximately equal to the price of nutrients bought from domestic producers. This allowed interpreting the production price index times the production subsidy index as equal to the farm price index of fertilizers. Implicit in this definition is an index of import tax as shown in the fourth column of table B-10.

Crop Prices Received

The index of prices received for 37 principal crops (table B-11) is based on the same items included in the crop production series. Data on farm prices received were those reported annually by the Direccion General de Economia Agricola, Mexican Secretariate of Agriculture. They were aggregated using 1960 Census quantity weights.

Table B-11.--Crop prices received, Mexico, 1940-65
(1960=100)

Year	Index	Year	Index	Year	Index
1940	14	1949	47	1957	109
1941	15	1950	59	1958	102
1942	18			1959	99
1943	24	1951	59		
1944	28	1952	63	1960	100
		1953	74	1961	107
1945	32	1954	75	1962	108
1946	38	1955	82	1963	118
1947	41			1964	123
1948	44	1956	93	1965	128

This index, divided by a simple average of the "prices paid" index for irrigation water (last column, table B-8), insecticides (last column, table B-9), and fertilizers (last column, table B-10), was the basis of the prices received over prices paid index discussed on pages 94-102.

Table B-12.--Mexico's production of primary fertilizer nutrients, 1940-65

Year	N	P	K
	Metric tons		
1940	1,130	2,270	124
1941	1,130	2,270	124
1942	1,120	1,243	134
1943	1,301	1,451	163
1944	1,360	1,535	176
1945	1,506	1,608	208
1946	1,675	1,694	238
1947	1,644	3,427	242
1948	1,593	2,969	226
1949	1,508	3,843	227
1950	1,109	3,329	153
1951	7,302	3,869	95
1952	10,742	10,899	703
1953	15,670	12,556	1,234
1954	13,331	11,615	96
1955	14,694	14,133	57
1956	19,074	14,872	523
1957	21,345	16,159	515
1958	24,554	15,089	671
1959	33,956	18,200	606
1960	49,943	17,674	556
1961	55,786	19,571	437
1962	74,700	36,775	515
1963	94,291	43,231	774
1964	116,689	42,837	709
1965	117,002	42,320	715

Source: (49).

Table B-13.--Mexico's imports of primary fertilizer nutrients, 1940-65

Year	To fiscal zone 1/			To free tax zone		
	N	P	K	N	P	K
	Metric tons					
1940	2,909	6	1,732	-	-	-
1941	4,485	7	2,818	-	-	-
1942	3,091	6	1,184	-	-	-
1943	4,753	29	2,790	-	-	-
1944	3,649	22	1,993	-	-	-
1945	4,926	40	2,702	-	-	-
1946	4,271	28	1,728	-	-	-
1947	9,245	53	3,800	-	-	-
1948	5,340	423	20	-	-	-
1949	5,649	226	624	-	-	-
1950	7,623	135	109	1,105	3	11
1951	7,088	470	123	1,823	104	142
1952	6,156	430	141	1,792	156	66
1953	4,891	1,752	333	1,074	350	664
1954	10,660	5,509	2,550	1,688	240	762
1955	23,403	4,411	3,698	2,307	385	1,156
1956	28,908	9,171	5,253	6,329	304	911
1957	29,072	10,943	6,767	5,649	295	883
1958	49,072	9,847	12,782	3,886	418	1,253
1959	61,083	10,728	10,563	3,359	258	774
1960	72,348	14,715	9,778	3,832	461	1,383
1961	70,757	17,089	10,076	2,741	541	1,624
1962	45,423	10,779	14,275	2,420	476	1,427
1963	59,724	4,178	13,817	2,406	481	1,444
1964	80,835	4,705	19,113	3,283	657	1,970
1965	82,995	6,570	21,685	3,103	540	1,820

1/ Subject to import taxes.

Source (49).

Direct Factor Share Estimates

Tables B-14 through B-16 show the basis for the 1960 factor share estimates used in chapter 4 of this report.

Tables B-14 and 15 show reported values and "equivalent rents," or costs, of employing inputs. Except for "other farmland" and "livestock capital," values were converted to rents by using a 15-percent interest rate. For calculation of the equivalent rent of the stock of labor, judgment estimates of employment and wage rates for all categries except "hired labor" were used. The "full-time equivalent numbers" shown for hired labor were estimated as the wage bill divided by the full-time wage calculated from the 1960 Mexican Census of Population.

Table B-16 simply summarizes the data of tables B-14 and B-15.

Table B-14.--Data used in computation of 1960 factor shares for inputs other than labor

Input category and principal components	Value data	
	Reported stock	"Equivalent rent"
	Million pesos	
Purchased inputs:		
Fertilizers		283
Insecticides		169
Purchased water		102
Irrigation facilities	1,922	288
Misc. expenses		548
Land:		
Cropland	23,059	3,459
Pastureland	8,278	1,242
Other farmland	32,107	963
Livestock capital:		
Cattle	12,178	2,436
Sheep	536	107
Pigs	1,307	261
Goats	856	171
Feed		739
Power and implements:		
Tractors	1,410	211
Threshers	267	40
Seeders, harvesters, and shellers	159	24
Plows and rakes	783	117
Cultivators, balers	412	62
Carts and trucks	995	149
Cottage-type tools	287	43
Work animals	2,396	359
Gas, oil, and lubricants		150
Hire of farm power		150
Misc. other equipment	291	45

Source: (34).

Table B-15.--Data used in computation of 1960 factor shares for labor inputs

Item	Unit	Type of labor: Hired	Large farmers	Small farmers	Ejido 1/	Family 2/
Reported numbers........	Thou.		447	899	1,598	3,265
Assumed proportion of year working...........	Pct.		1.00	0.67	0.67	0.50
Full-time equivalent numbers................	Thou.	357	447	602	1,070	1,632
Assumed or calculated wage..................	Pesos	4,248	2,000	2,000	2,000	1,000
"Equivalent rent".......	Mil. pesos	1,517	894	1,204	2,104	1,632

1/ Includes "ejidatarios" reported by the Census as "in agriculture."
2/ These are termed by the Census as "unpaid family workers."

Source: (34) and (35).

Table B-16.--Computation of 1960 factor shares for Mexican agriculture

Input category	Estimated cost	"Corrected" cost 1/	Estimated share
	Million pesos		
Purchased inputs........	$1,390	$1,439	0.071
Hired labor.............	1,517	1,571	0.078
Farmers, large..........	894	926	0.046
Farmers, small..........	1,204	1,247	0.062
Ejidatarios.............	2,140	2,216	0.110
Family labor............	1,632	1,690	0.083
Land....................	5,664	5,863	0.291
Livestock capital.......	3,714	3,845	0.190
Power and implements....	1,350	1,398	0.069
Total inputs............	19,505	20,195	1.000
Total output............	20,195	20,195	
Correction factor 2/....	1.03537	---	

1/ All cost figures in this column have been inflated by the "correction factor" of 1.03537.
2/ This is the ratio of the value of "total output" to "total input."

Source: Tables B-14 and B-15.

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